1991
Ambient Air Quality Report

Ambient Monitoring Section
George C. Murray, Jr., Chief

Division of Air Quality
Alan W. Klimek P.E., Director

Published
March 1997

State of North Carolina
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DEHNR

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Foreword

This report is issued by the Division of Air Quality of the Department of Environment, Health, and Natural Resources to inform the public of air pollution levels throughout the state of North Carolina. It describes the sources and effects of the following pollutants for which the U.S. Environmental Protection Agency and the State of North Carolina have established ambient air quality standards:

Particulate Matter	Nitrogen Dioxide
Carbon Monoxide	Ozone
Sulfur Dioxide	Lead

A brief discussion of the ambient air monitoring program, including a description of the monitoring network, is provided. Detailed results are presented of monitoring that was conducted in 1991 to measure the outdoor concentrations. The data are presented graphically and as statistical summaries, including comparisons to the ambient air quality standards. The report discusses the recorded data, seasonal variability of some pollutants. Data and areas exceeding the ambient air quality standards are identified. Factors which have contributed to those exceedances are also described.

Acid rain data from the National Atmospheric Deposition Program/National Trends Network for North Carolina is also included for 1991. An account of pollutant concentration trends through 1991 concludes the report. Data collected after 1991 will be discussed in later reports.

Current air pollution information is available to the public 24 hours a day through the use of the air quality index telephone numbers listed below:

Statewide toll-free[1]	888-AIR-WISE
Charlotte area	703-333-SMOG
Durham area	919-733-DATA
Fayetteville area	919-486-9413
Raleigh area	919-733-DATA

Additional copies of this report and previous annual reports are available from

Division of Air Quality
Department of Environment, Health, and Natural Resources
P O Box 29580
Raleigh, North Carolina 27626-0580

Comments regarding this report or suggestions for improving future reports are welcomed. Comments may be sent to Dr. Wayne L. Cornelius, at the above address.

Alan W. Klimek, P.E., Director
Division of Air Quality

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[1]Starting in Fourth Quarter 1996.

Executive Summary

In 1991, 300,563 air quality samples were collected by the North Carolina Division of Environmental Management (DEM) and the three local program agencies (listed in Appendix A). These samples included measurements of the U.S. Environmental Protection Agency (EPA) criteria pollutants: particulate matter, carbon monoxide, ozone, sulfur dioxide, and nitrogen dioxide. A discussion of each pollutant is given, and summary tables, maps, charts and explanations of the data are presented.

Weekly acid rain samples collected by the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) at seven North Carolina sites and one Tennessee site very close to the North Carolina border were also used in this report. A discussion of acid rain is given, and summary tables, maps, charts and explanations of the data are presented.

A report of pollutant trends from 1972 (or the earliest year available) through 1991 has been added to this report. In the summary below, comments about trends will be made only for those pollutants having either increasing or decreasing tendencies.

Two different types of **Particulate matter** were sampled in North Carolina during 1991. Total Suspended Particulate (TSP), generally considered to be particles having an aerodynamic diameter of 45 micrometers or less, is regulated by North Carolina standards. Particulate matter (PM_{10}) with an aerodynamic diameter less than or equal to a nominal 10 micrometers (0.00004 inches) is regulated by both EPA and N.C. standards.

TSP was sampled at 37 sites, yielding 1,980 24-hour samples. Three exceedances of the state TSP ambient air quality standard for 24-hour samples (150 $\mu g/m^3$) were observed in 1991, at the Corporation Parkway, Winston-Salem site in Forsyth County, the Canton site in Haywood County, and the Plymouth site in Washington County. The Plymouth exceedance was associated with an "exceptional event" (*viz.*, sandblasting).

PM_{10} was sampled at 21 sites, yielding 1,179 24-hour samples. There were no exceedances of the National Ambient Air Quality Standards for PM_{10} (150 $\mu g/m^3$ for 24-hour samples and 50 $\mu g/m^3$ for the annual arithmetic mean). Mean 24-hour concentrations have remained approximately constant since 1985.

Carbon monoxide (CO) is the most commonly occurring pollutant and is largely the result of fuel combustion. The most likely areas to have excessive CO concentrations are the larger cities where there are more cars and congested city streets.

CO was sampled at 15 sites, yielding 115,441 valid hourly averages. The National Ambient Air Quality Standards for CO are 35 ppm for the maximum one-hour average and 9 ppm for the maximum eight-hour average. There were no exceedances of the one-hour average standard, but one exceedance of the eight-hour standard occurred at the Person Street, Raleigh site in Wake

County. The mean one-hour average has been decreasing by about five percent per year, and the mean eight-hour average has been decreasing by about 3.7 percent per year. The combined effects of newer cars in the vehicle fleet, traffic control strategies, and the Inspection and Maintenance program in Wake County have helped to reduce the number and intensity of CO exceedances from previous years.

Ozone (O_3) forms in the lower atmosphere when hydrocarbons (or volatile organic compounds) and nitrogen oxides chemically react in the presence of sunlight and high temperatures. The main emphasis in control of ozone has been to control hydrocarbon emissions.

O_3 was sampled at 23 sites, yielding 104,087 valid hourly averages. The National Ambient Air Quality Standard for O_3 is 0.12 ppm for the maximum one-hour average. Three exceedances occurred in North Carolina in 1990, and six occurred in 1989.

In 1991, there was only one exceedance of the standard, at the Westinghouse Blvd. (also called Arrowwood Blvd.), Charlotte site in Mecklenburg County. Mecklenburg County continues to be designated an ozone nonattainment area, and hydrocarbon control strategies are being used to reduce the historical ozone problem there.

Sulfur dioxide (SO_2) is mainly produced by combustion of fossil fuels containing sulfur compounds and the manufacture of sulfuric acid.

SO_2 was sampled at 10 sites, yielding 51,073 valid hourly averages. There were no exceedances of the National Ambient Air Quality Standards (365 $\mu g/m^3$ for a 24-hour average, 1300 $\mu g/m^3$ for a three-hour average, 80 $\mu g/m^3$ for the annual arithmetic mean).

Nitrogen oxides (NO_x) occur primarily as a result of the burning of fossil fuels such as coal, oil and gasoline, due to the oxidation of atmospheric nitrogen and nitrogen compounds in the fuel. The primary combustion product is NO, which reacts with hydrocarbons, ozone and other atmospheric compounds to form NO_2. NO_x compounds play an important role in the formation of ozone. NO_x monitoring was performed in Charlotte, Raleigh, and Winston-Salem to gather data for the development of control strategies for ozone nonattainment areas.

The criteria pollutant NO_2 was sampled at four sites, yielding 26,803 valid hourly averages. There were no exceedances of the National Ambient Air Quality Standard (0.053 ppm for the annual arithmetic mean). The mean one-hour average concentration has been decreasing by about 2.8 percent per year.

Lead (Pb) emissions result from coal combustion and sandblasting of highway structures and water tanks; a major source in the past was the combustion of gasoline containing tetraethyl lead as an additive.

Although no lead samples were reported in 1991, there were no recent exceedances of the

ambient air quality standard for lead (1.5 $\mu g/m^3$ for a quarterly arithmetic mean). Mean lead concentrations have been decreasing by 17 to 40 percent per year in recent years. The steady decline in the use of leaded gasoline is primarily responsible for this trend.

Acid Rain is produced when nitrate and sulfate ions from automobile and industrial sources are released into the upper atmosphere, undergo a reaction with moisture in the air and are deposited as acid precipitation. Monitoring of pH and and other ion concentrations in precipitation will help to identify trends and demonstrate the results of efforts made to reduce emissions from mobile and industrial sources.

The annual mean pH in 1991 ranged from 4.44 (Rowan County) to 4.61 (Mt. Mitchell in Yancey County).

CONTENTS

List of Tables

List of Figures

1. Introduction

This monograph is primarily an annual report for the ambient air monitoring performed in calendar year 1991 by the North Carolina Division of Environmental Management (DEM) and four local air pollution agencies which are more fully described in Appendix A. (The DEM was superseded in 1996 by the Division of Air Quality [DAQ].)

There were 300,563 air quality samples of the U.S. Environmental Protection Agency (EPA) criteria pollutants, particulate matter, carbon monoxide, ozone, sulfur dioxide, and nitrogen dioxide reported herein. No samples of another criteria pollutant, lead, were taken in 1991.

The overall organization of this report differs from its predecessors and includes new features, such as better graphics and a trends chapter. Chapter 2 contains descriptions of the criteria pollutants, including their sources and their effects on human health, plants and animals. Chapter 3 outlines the standards applied to criteria pollutant concentrations established by EPA and the state of North Carolina to protect human health (primary standards) and plants, animals, and property (secondary standards). Chapter 4 describes the ambient monitoring program conducted by DEM and four local program agencies. Chapter 5 gives detailed monitoring results, with sections for each pollutant consisting of a map of the monitor sites, a table of the monitor summary statistics relevant to the standards, one or more maps summarizing the important statistics for each county with monitors, and additional summaries as appropriate to each individual pollutant. In Chapter 6, the EPA Air Quality Index for the criteria pollutants is described, and charts of Air Quality Index measurements for four Metropolitan Statistical Areas of North Carolina are charted. Chapter 7 treats sources, effects and monitoring of acid rain data conducted in North Carolina by the National Atmospheric Deposition Program and National Trends Network (NADP/NTN); the calendar year mean pH level is displayed by counties on a map, and site statistics for the calendar year are given in two tables. Chapter 8 provides a statewide summary of trends for the criteria pollutants from the early 1970s (1985 for PM_{10}) and pH values from 1978 through 1991.

2. Description of Criteria Pollutants

2.1. Particulate Matter

Atmospheric particulate matter is defined as any airborne material, except uncombined water (water, mist, steam, etc.) which exists in a finely divided form as a liquid or solid at standard temperature (25°C) and pressure (760 mm mercury) and has an aerodynamic diameter of less than 100 micrometers. Currently, two sizes of particulate matter are monitored, total suspended particulate (TSP) and PM_{10}. TSP is any particulate matter measured by the method described in EPA regulations 40 CFR 50 App. B (Office of the Federal Register 1993, p. 715-728) and is generally considered to be particles having an aerodynamic diameter of 45 micrometers or less. PM_{10} is particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers as measured according to EPA regulations 40 CFR 50 App. J (Office of the Federal Register 1993, p. 769-773). TSP measurements have been made in North Carolina since the early 1960s and PM_{10} has been sampled locally in Charlotte since 1985 and statewide since 1986 (North Carolina Department of Environment, Health, and Natural Resources 1991).

2.1.1. Sources

Particulates are emitted by many of man's activities, such as fuel used in combustion, motor vehicle operation, industrial processes, grass mowing, agricultural tilling and open burning. Natural sources include windblown dust, forest fires, volcanic eruptions and pollen released from vegetation.

Particles emitted directly from a source may be either fine (less than 2.5 micrometers) or coarse (2.5 - 60 micrometers), but particles formed in the atmosphere will usually be fine. Generally, coarse particles have very slow settling velocities and are characterized as suspended particulate matter. Typically, fine particles originate by condensation of materials produced during combustion or atmospheric transformation.

2.1.2. Effects

Particulate matter can be responsible for health effects affecting the breathing system, including aggravation of existing lung and heart disease, limitation of lung clearance, changes in form and structure of organs, and development of cancer. Individuals most sensitive to the effects of

particulate matter include those with chronic obstructive lung or heart disease, those suffering from the flu, asthmatics, the elderly, children, and mouth breathers.

Health effects from inhaled particles are influenced by the depth of penetration of the particles into the respiratory system, the amount of particles deposited in the respiratory system, and by the biological reaction to the deposited particles. The risks of adverse health effects are greater when particles enter the tracheobronchial and alveolar portions of the respiratory system. Small particles can penetrate into these deeper regions of the respiratory system. Healthy respiratory systems can trap particles larger than 10 micrometers more efficiently before they move deeply into the system and can more effectively remove the particles that are not trapped before deep movement.

Particulate matter can also interfere with plant photosynthesis, by forming a film on leaves reducing exposure to sunlight. Particles can also cause soiling and degradation of property, which can be costly in terms of cleaning and maintaining surfaces.

Suspended particles can absorb and scatter visible light, causing reduction of visibility. This is a national concern, especially in areas such as national parks, historic sites and scenic attractions visited by sightseers.

2.2. Carbon Monoxide

Carbon monoxide (CO) is the most commonly occurring air pollutant. CO is a colorless and poisonous gas produced by incomplete burning of carbon-containing fuel.

2.2.1. Sources

Most atmospheric CO is produced by incomplete combustion of fuels used for vehicles, space heating, industrial processes and solid waste combustion. Transportation activities account for the majority of CO emissions. Boilers and other fuel burning heating systems are also significant sources.

2.2.2. Effects

Breathing carbon monoxide affects the oxygen-carrying capacity of the blood. Hemoglobin in the blood binds with CO more readily than with oxygen, starving the body of vital oxygen.

Individuals with anemia, lung and heart diseases are particularly sensitive to CO effects. Low concentrations affect mental function, vision and alertness. High concentrations can increase fatigue, reduce work capacity and may adversely affect fetal development. Chronic exposure to CO at concentrations as low as 70 ppm (80 mg/m^3) can cause cardiac damage. Other health effects associated with exposure to CO include central nervous system effects and pulmonary function difficulties.

Ambient CO concentrations apparently do not adversely affect vegetation or materials.

2.3. Ozone

Ozone is a clear gas which forms in the troposphere (lower atmosphere) by chemical reactions involving hydrocarbons (or volatile organic compounds) and nitrogen oxides in the presence of sunlight and high

temperatures. Even low concentrations of tropospheric ozone are harmful to people and animals, vegetation and materials. Ozone is the most widespread and serious criteria air pollutant in North Carolina.

Ozone in the upper atmosphere (stratosphere) shields the earth from harmful effects of ultraviolet solar radiation. Stratospheric ozone can be damaged by the emission of chlorofluoro-hydrocarbons (CFCs) such as Freon.

2.3.1. Sources

Ozone (O_3) is the major compound of a complex mixture of compounds known as photochemical oxidants. Ozone is not usually emitted directly into the atmosphere, but is formed by a series of complex reactions involving hydrocarbons, nitrogen oxides and sunlight. Ozone concentrations are higher during the daytime in late spring, summer and early autumn when the temperature is above 60°F and the sunlight is more intense.

Two natural sources of upper atmosphere ozone are solar radiation and electrical discharge during thunderstorms. These are not significant sources of tropospheric ozone.

2.3.2. Effects

Ozone is a pulmonary irritant, affecting the respiratory mucous membranes, as well as other lung tissues and respiratory functions. Ozone has been shown to impair normal function of the lung–causing shallow, rapid breathing and a decrease in pulmonary function. Other symptoms of exposure include chest tightness, coughing and wheezing. People with asthma, bronchitis or emphysema will probably experience breathing difficulty when exposed to short-term concentrations between 0.15 and 0.25 ppm. Continued or repeated long-term exposure may result in permanent lung structure damage.

Ozone damages vegetation by injuring plant leaves. Ozone also accelerates material aging–cracking rubber, fading dyes and eroding paint.

2.4. Sulfur Dioxide

Sulfur dioxide (SO_2) is a colorless, corrosive, harmful gas with a pungent odor. Smaller concentrations of sulfur trioxide and other sulfate compounds are also found in SO_2 emissions. Sulfur oxides contribute to the formation of acid rain and the formation of particles which reduce visibility.

2.4.1. Sources

The main sources of SO_2 are combustion of fossil fuels containing sulfur compounds and the manufacture of sulfuric acid. Other sources include refining of petroleum and smelting of ores that contain sulfur.

2.4.2. Effects

The most obvious health effect of sulfur dioxide is irritation and inflammation of body tissues brought in contact with the gas. Sulfur dioxide can increase the severity of existing respiratory diseases such as asthma, bronchitis, and emphysma. Sulfuric acid and fine particulate sulfates may also cause significant health problems.

2.5. Nitrogen Oxides

Several gaseous oxides of nitrogen are normally found in the atmosphere, including nitrous oxide (N_2O), nitric oxide (NO) and nitrogen dioxide (NO_2). Nitrous oxide is a stable gas with anesthetic characteristics and typical ambient concentrations well below the threshold concentration for a biological effect. Nitric oxide is a colorless gas with ambient concentrations generally low enough to have no significant biological effect. Nitrogen dioxide is reddish-brown but is not usually visible at typical ambient concentrations.

2.5.1. Sources

The most significant nitrogen oxide emissions occur as a result of the burning of fossil fuels such as coal, oil and gasoline, due to the oxidation of atmospheric nitrogen and nitrogen compounds in the fuel. The primary combustion product is NO, which reacts with hydrocarbons, ozone and other atmospheric compounds to form NO_2.

2.5.2. Effects

At typical concentrations, nitrogen dioxide has significant health effects as a pulmonary irritant, especially upon asthmatics and children. In North Carolina a much greater health concern is the formation of ozone which is promoted by the presence of NO_2 and other nitrogen oxides.

Some types of vegetation are very sensitive to NO_2, including oats, alfalfa, tobacco, peas and carrots. Chronic exposure causes chlorosis (yellowing) and acute exposure usually causes the appearance of irregularly shaped lesions on the leaves.

Nitric oxide and nitrogen dioxide do not cause direct damage to materials. However NO_2 can react with moisture in the atmosphere to produce nitric acid, which corrodes metal surfaces and contributes to acid rainfall.

High concentrations of NO_2 may cause reduction of visibility. A significant portion of the brownish coloration sometimes observed in polluted air in winter months may be due to NO_2.

2.6. Lead

Lead is a ubiquitous, toxic heavy metal element occurring in the atmosphere as small particles.

2.6.1. Sources

The major source of atmospheric lead used to be the combustion of gasoline containing the additive tetraethyl lead as an antiknock agent; but the availability of leaded fuel has declined, and the concentration of lead in such fuel has been decreasing, minimizing gasoline as a source. Significant remaining sources include coal combustion (lead exists in very small quantities as an impurity in coal) and sandblasting of highway structures and water tanks. Lead is also used in batteries, paints, insecticides and newspaper inks.

2.6.2. Effects

Lead (Pb) persists and accumulates in the environment and in the human body. It may be inhaled ingested, and is eventually absorbed into the bloodstream and distributed to all body tissues. Exposure to low concentrations interferes with blood

2.6.2. Effects

Lead (Pb) persists and accumulates in the environment and in the human body. It may be inhaled ingested, and is eventually absorbed into the bloodstream and distributed to all body tissues. Exposure to low concentrations interferes with blood production and specific enzyme systems. It is believed to be a cause of kidney and nerve cell damage, and severe lead poisoning has been documented as a cause of brain damage in children.

3. Standards

Ambient air quality status is determined by measuring ambient pollutant concentrations and comparing the measured concentrations to the corresponding standard. The US EPA (Environmental Protection Agency) defines the ambient air as "that portion of the atmosphere, external to buildings, to which the general public has access."

Ambient air quality standards are classified as primary and secondary. Primary standards are those established to allow an adequate margin of safety for protection of public health. Secondary standards are those established to provide an adequate margin of safety to protect the public welfare from adverse effects. Secondary standards take into account pollution effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, climate, property, transportation, economy, personal comfort, and well-being. The scientific criteria upon which the standards are based are periodically reviewed by EPA, and the standards are reestablished or changed according to their findings.

A measurement of a pollutant that is greater than the ambient air quality standard for a specific averaging time is called an "exceedance". The national primary, secondary and North Carolina ambient air quality standards are summarized in Table 1.

Table 1. National and North Carolina Ambient Air Quality Standards

Pollutant	Type of Average	Standard Level Concentration		
		Primary (Health Related)	Secondary (Welfare Related)	North Carolina
TSP	Annual Geom. Mean	NA[a]	NA[a]	75 $\mu g/m^3$
	24-hour	NA[a]	NA[a]	150 $\mu g/m^3$([b])
PM-10	Expected Annual Arith. Mean	50 $\mu g/m^3$	50 $\mu g/m^3$	50 $\mu g/m^3$
	24-hour[c]	150 $\mu g/m^3$	150 $\mu g/m^3$	150 $\mu g/m^3$
CO	8-hour[b]	9 ppm (10 mg/m^3)[d]	NA	9 ppm (10 mg/m^3)
	1-hour[b]	35 ppm (40 mg/m^3)	NA	35 ppm (40 mg/m^3)
O_3	Maximum Daily 1-hour Average[e]	0.12 ppm (235 $\mu g/m^3$)	0.12 ppm (235 $\mu g/m^3$)	0.12 ppm (235 $\mu g/m^3$)
SO_2	Annual Arith. Mean	80 $\mu g/m^3$ (0.03 ppm)	NA	80 $\mu g/m^3$
	24-hour[b]	365 $\mu g/m^3$ (0.14 ppm)	NA	365 $\mu g/m^3$ (0.14 ppm)
	3-hour[b]	NA	1,300 $\mu g/m^3$ (0.50 ppm)	1,300 $\mu g/m^3$ (0.50 ppm)
NO_2	Annual Arith. Mean	0.053 ppm (100 $\mu g/m^3$)	0.053 ppm (100 $\mu g/m^3$)	0.053 ppm (100 $\mu g/m^3$)
Pb	Maximum Quarterly Arith. Mean	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$

a. National TSP standards were discontinued in 1987 and superseded by standards for PM_{10}.

b. Not to be exceeded more than once per year.

c. The standard is attained when the expected number of days per calendar year (following 40 CFR 50 App. K [Office of the Federal Register 1993, p. 773-777]) above the standard concentration is less than or equal to 1.0.

d. Concentrations in parentheses are approximately equivalent to the adjacent specified standard.

e. The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations (following 40 CFR 50 App. H [Office of the Federal Register 1993, p. 767-769]) above the standard concentration is equal to or less than 1.0.

4. Ambient Air Quality Monitoring Program

Ambient monitoring and analysis of samples were conducted by the Division of Environmental Management and three local air pollution control programs (Appendix A). The air monitoring data collected are used to determine whether air quality standards are being met, to assist in enforcement actions, to determine the improvement or decline of air quality, and to determine the extent of allowable industrial expansion. A list of monitoring sites active in 1991 is presented in Table 5.1. Maps showing the locations of sites are given in Figures 5.1, 5.4, 5.7, 5.12, 5.16, and 5.19.

Siting of monitors involves several considerations, including size of the area represented, distance from roadways and nearby sources, unrestricted air flow, safety, availability of electricity, and security.

Each site has a defined monitoring objective, and annual evaluations are conducted to ensure that the objectives are met. The four basic monitoring objectives are:

- to determine the highest concentration expected in an area
- to determine representative concentrations in areas of high population density
- to determine the impact of significant sources or source categories on ambient air quality
- to determine general background concentration levels.

All monitors have known precision, accuracy, interferences and operational parameters. The monitors–as well as all measurement devices–are carefully calibrated at predetermined frequencies, varying from daily to quarterly. Measurements are traceable to National Institute of Standards and Technology (NIST), when standards are available.

Monitoring and analyses are performed according to a set of standard operating procedures. Field personnel visit manual sampling sites once every six days to replace sample media and check the operation and calibration of monitors. Personnel check continuous monitors at least twice weekly for correct instrument operation.

Quality assurance activities are carried out to determine the quality of the collected ambient data, improve the quality of the

data and evaluate how well the monitoring system operates. The objective of the quality assurance activities is to produce high quality air pollution data with defined completeness, precision, accuracy, representativeness and comparability.

Microprocessors are used at most sites to collect the data. A computerized telemetry system aids in assembly of the data for submission to the US EPA. This enhances data validity, minimizes travel costs, and allows real-time data to be available by computer polling when needed. Numerous checks are performed to ensure that only valid data are reported.

5. Pollutant Monitoring Results

Air quality in a given area is affected by many factors, including meteorological conditions and the location of pollutant sources and amount of pollutants emitted from them.

The speed and direction of air movement determine whether pollutant emissions cause exceedances of the ambient air quality standards and where those exceedances will occur. Atmospheric stability, precipitation, solar radiation and temperature also affect pollutant concentrations.

Geographic factors that affect concentrations include variables such as whether an area is urban or rural, and whether the area has mountains, valleys or plains.

Important economic factors affecting air quality include concentration of industries, conditions of the economy, and the day of the week.

Air quality may also be influenced by "exceptional events" in the short term. Exceptional events may be either natural (e.g., forest fire) or manmade (e.g., construction or demolition). Unusual data that can be attributed to an exceptional event is considered biased and may be omitted from data summaries where it is not representative of normal conditions. In the tabular listings in this report, data affected by exceptional events are included but flagged, and they are omitted from summaries in charts. A list of typical exceptional events is given in Appendix B.

Data for the 1991 ambient air quality report were collected at 131 air pollutant monitors operated by state and local agencies in North Carolina (listed in Appendix A). To save operating costs, some ozone monitors and sulfur dioxide monitors are operated only every third year. Sixteen of the 131 monitors used for this report operated most recently in 1989 or 1990. Lead concentration data are collected annually by the state and local agencies; but they are analyzed by EPA, and the availability of the data may be more delayed than that of other pollutants. The most recent lead data available to report are from 1990 and involve 5 of the 131 monitors.

5.1. Total Suspended Particulate

Total Suspended Particulate matter is collected on filters using a "high volume" sampler method (an EPA Reference Method). The high volume motor is set and calibrated to an air flow rate of 40 ±4 $feet^3$/min. Gravimetric analysis is performed by comparing the exposed filter weight to the unexposed filter weight. Weights are measured to the nearest 0.1 milligram. The difference between the exposed and unexposed weights is the amount of particulate collected from a known volume of air.

In 1991 37 sites were used to monitor TSP and 1,980 samples were collected. A map of the TSP sampling sites is presented in Figure 5.1, and a detailed summary of the data from each site is given in Table 5.1.

Only three samples exceeded the N.C. TSP ambient air quality standards, compared to two exceedances in 1990 and four in 1989. A description of the 1991 exceedances is given in Table 5.2. Attainment status is based on the second highest 24-hour concentration and on the geometric mean of all the 24-hour concentrations at a given site. Three sites produced one maximum 24-hour sample with a concentration exceeding the standard; however, one of these was associated with an "exceptional event" (sandblasting), and the other two were not violations because the second maximums at these sites were below the standard. The largest geometric mean TSP average was 67 $\mu g/m^3$, which is 90% of the level of the air quality standard.

The second highest 24-hour concentrations are charted by county in Figure 5.2 and the annual geometric means are similarly charted in Figure 5.3. (In counties with more than one TSP monitoring site, the concentration reported in Figure 5.2 is the county-wide second largest concentration, and the geometric mean reported in Figure 5.3 is the maximum geometric mean for the county.)

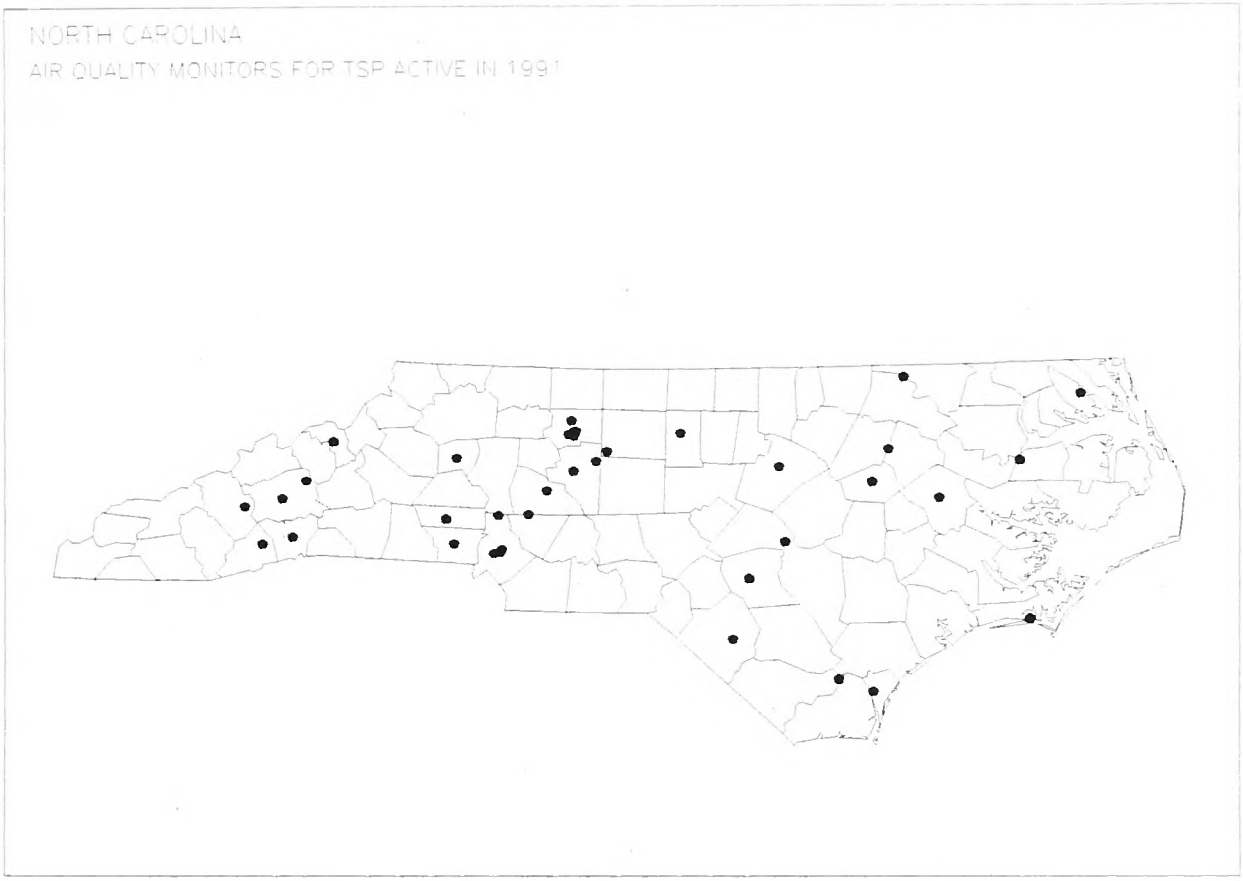


Figure 5.1. Location of TSP Monitoring Sites

Table 5.1. Total Suspended Particulates[b] in Micrograms Per Cubic Meter (µg/m^3) for 1991.

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	24 HOUR MAXIMA			ARITH MEAN	GEOM MEAN	GEOM SD	EXCEEDANCES		
		1ST	2ND	3RD				PRIMARY		SECOND-ARY
								# >260	GM>75	#>150
ALAMANCE 37-001-0001 1136 E.WEBB AVE. BURLINGTON	56	102	98	83	44.8	40.9	1.56			
ALEXANDER 37-003-0003 STATE ROAD 1177 TAYLORSVILLE	60	110	102	77	39.2	36.1	1.49			
BUNCOMBE 37-021-0003 HEALTH & SOCIAL SERVICES BLDG WOODFIN ST ASHEVILLE	59	72	68	56	32.4	30.1	1.49			
CABARRUS 37-025-0004 FLOYD ST. KANNAPOLIS	55	100	98	91	48.5	45.3	1.44			
CARTERET 37-031-0003 ARENDELL & 4TH MOREHEAD CITY	56	76	75	70	41.1	38.2	1.50			
CATAWBA 37-035-0004 1650 1ST. ST. HICKORY	49	118	104	94	56.3	52.8	1.45			

[b]This table summarizes all valid TSP data, including samples affected by exceptional events.

Table 5.1: Total Suspended Particulates in Micrograms Per Cubic Meter ($\mu g/m^3$) for 1991 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	24 HOUR MAXIMA 1ST	2ND	3RD	ARITH MEAN	GEOM MEAN	GEOM SD	EXCEEDANCES PRIMARY # >260	GM>75	SECOND-ARY #>150
COLUMBUS 37-047-0001 HWY 87 ACME-DELCO	59	101	61	58	35.5	32.5	1.56			
CUMBERLAND 37-051-0004 F.S. # 5 3296 VILLAGE DR. FAYETTEVILLE	56	89	83	80	48.4	45.4	1.46			
DAVIDSON 37-057-0002 S.SALISBURY ST. LEXINGTON.	51	103	93	89	51.4	47.9	1.47			
DAVIDSON 37-057-1001 CITY HALL 7 WEST GUILFORD ST THOMASVILLE	58	101	101	99	48.1	44.3	1.51			
EDGECOMBE 37-065-0002 LEGETT RD., WASTE TREATMENT PLANT ROCKY MOUNT	60	93	86	83	44.0	39.3	1.66			
FORSYTH 37-067-0013 720 RIDGE AVENUE WINSTON-SALEM	33	88	80	78	45.6	42.6	1.44			
FORSYTH 37-067-0020 SILAS CREEK PKWY AT HAWTHORNE RD WINSTON-SALEM	60	114	93	83	42.4	39.2	1.47			

Table 5.1: Total Suspended Particulates in Micrograms Per Cubic Meter (μg/m^3) for 1991 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	24 HOUR MAXIMA			ARITH MEAN	GEOM MEAN	GEOM SD	EXCEEDANCES		
		1ST	2ND	3RD				PRIMARY		SECOND-ARY
								# >260	GM>75	#>150
FORSYTH 37-067-0021 SIXTH & BROAD ST FRIENDS CHURCH WINSTON-SALEM	35	114	93	74	40.0	35.8	1.59			
FORSYTH 37-067-0023 1401 CORPORATION PARKWAY WINSTON-SALEM	55	152	137	132	73.1	67.2	1.52			
FORSYTH 37-067-0024 NORTH FORSYTH HIGH SCHOOL WINSTON-SALEM	40	110	72	57	38.7	36.1	1.45			
GASTON 37-071-0014 RANKIN LAKE RD, GASTONIA	54	114	81	73	38.7	35.5	1.51			
GUILFORD 37-081-1005 E GREEN & S CENTENNIAL ST HIGH POINT	51	94	87	83	48.0	44.8	1.45			
HALIFAX 37-083-0002 NE CORNER OF 5TH & CAROLINA ST. ROANOKE RAPIDS	59	111	102	89	47.8	43.7	1.54			
HARNETT 37-085-0001 MUNICIPAL BUILDING DUNN	59	99	91	91	50.7	47.1	1.49			

Table 5.1: Total Suspended Particulates in Micrograms Per Cubic Meter ($\mu g/m^3$) for 1991 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	24 HOUR MAXIMA			ARITH MEAN	GEOM MEAN	GEOM SD	EXCEEDANCES		
		1ST	2ND	3RD				PRIMARY		SECOND-ARY
								# >260	GM>75	#>150
HAYWOOD 37-087-0002 CANTON FIRE DEPT. CANTON	15	153	101	80	61.0	54.8	1.59			
HENDERSON 37-089-1005 US 25 & US 64 HENDERSONVILLE	58	128	82	80	47.9	44.5	1.47			
LINCOLN 37-109-0002 JAIL LINCOLNTON	47	119	86	78	49.7	47.2	1.38			
MECKLENBURG 37-119-0001 600 EAST TRADE STREET CHARLOTTE	58	115	87	81	46.6	43.0	1.52			
MECKLENBURG 37-119-0003 FIRE STA #11 620 MORETZ STREET CHARLOTTE	56	114	110	99	50.9	47.1	1.49			
MECKLENBURG 37-119-0010 FIRE STA #10 2136 REMOUNT ROAD CHARLOTTE	58	96	76	69	40.8	38.3	1.44			
MECKLENBURG 37-119-1001 FILTER PLANT DAVIDSON	58	120	69	66	37.4	34.0	1.55			

Table 5.1: Total Suspended Particulates in Micrograms Per Cubic Meter ($\mu g/m^3$) for 1991 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	24 HOUR MAXIMA			ARITH MEAN	GEOM MEAN	GEOM SD	EXCEEDANCES		
		1ST	2ND	3RD				PRIMARY		SECOND-ARY
								# >260	GM>75	#>150
MITCHELL 37-121-0001 CITY HALL SUMMIT ST SPRUCE PINE	52	135	129	103	48.8	43.9	1.57			
NEW HANOVER 37-129-0005 NINTH AND ORANGE STREETS WILMINGTON	55	82	81	73	40.8	37.8	1.51			
PASQUOTANK 37-139-0001 WATER PLANT N WILSON ST ELIZABETH CITY	60	87	86	70	37.7	34.0	1.60			
PITT 37-147-0003 1500 BEATTY ST GREENVILLE	59	93	90	86	49.1	45.2	1.52			
ROBESON 37-155-0003 SO. WATER ST. LUMBERTON	59	95	94	86	41.8	37.8	1.61			
ROWAN 37-159-1005 CHURCH ST SALISBURY	51	98	96	93	46.2	42.1	1.56			
TRANSYLVANIA 37-175-0002 HWY 64 BREVARD	56	111	100	79	43.8	40.8	1.46			

Table 5.1: Total Suspended Particulates in Micrograms Per Cubic Meter ($\mu g/m^3$) for 1991 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	24 HOUR MAXIMA 1ST	 2ND	 3RD	ARITH MEAN	GEOM MEAN	GEOM SD	EXCEEDANCES PRIMARY # >260	 GM>75	 SECOND-ARY #>150
WAKE 37-183-0003 FIRE STATION #9 SIX FORKS RD NORTH HILLS RALEIGH	60	83	79	75	38.3	35.0	1.54			
WASHINGTON 37-187-0002 OLD ACRE RD. PLYMOUTH	58	180	96	77	42.9	38.2	1.60			1[c]
WILSON 37-195-0002 N.W. CORNER OF KENAN ST.& TARBORO ST. WILSON	55	80	79	79	44.3	40.6	1.53			
Total Samples	1980									
Total Sites Sampled	37									

[c]Sandblasting occurrence 23 June 1991.

Table 5.2. TSP Exceedances in 1991.

COUNTY SITE NUMBER CITY	DATE	TSP VALUE ($\mu g/m^3$)	EXCEPTIONAL EVENT
FORSYTH 37-067-0023 WINSTON-SALEM	11 June 1991	152	
HAYWOOD 37-087-0002 CANTON	11 February 1991	153	
WASHINGTON 37-187-0002 PLYMOUTH	23 July 1991	180	Sandblasting

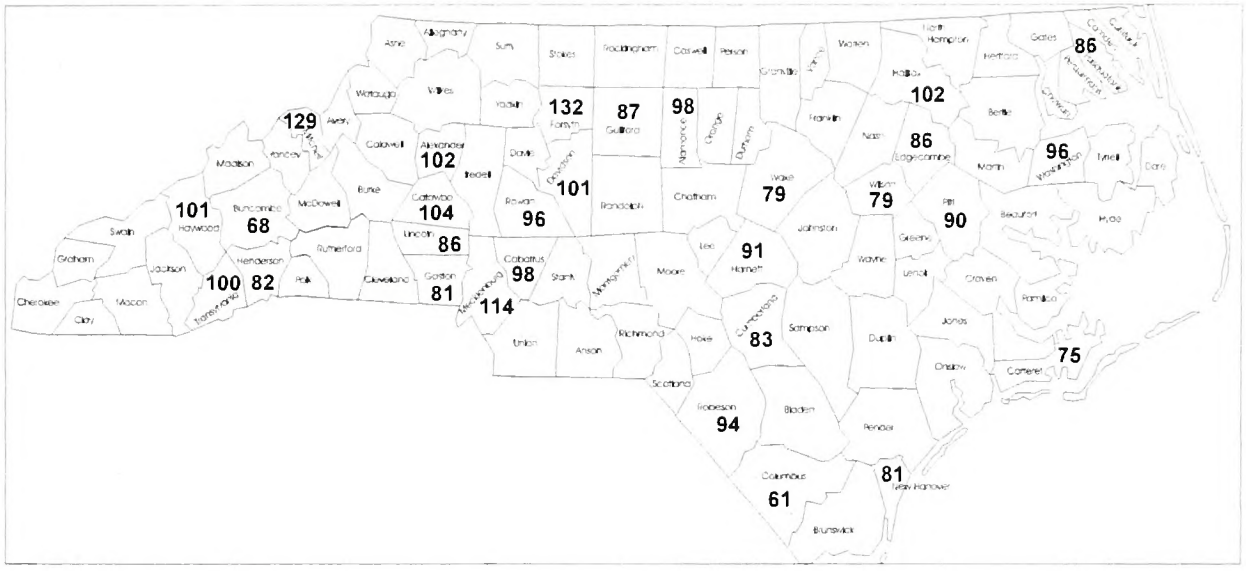


Figure 5.2. Total Suspended Particulates: Second Highest 24-Hour Averages, 1991

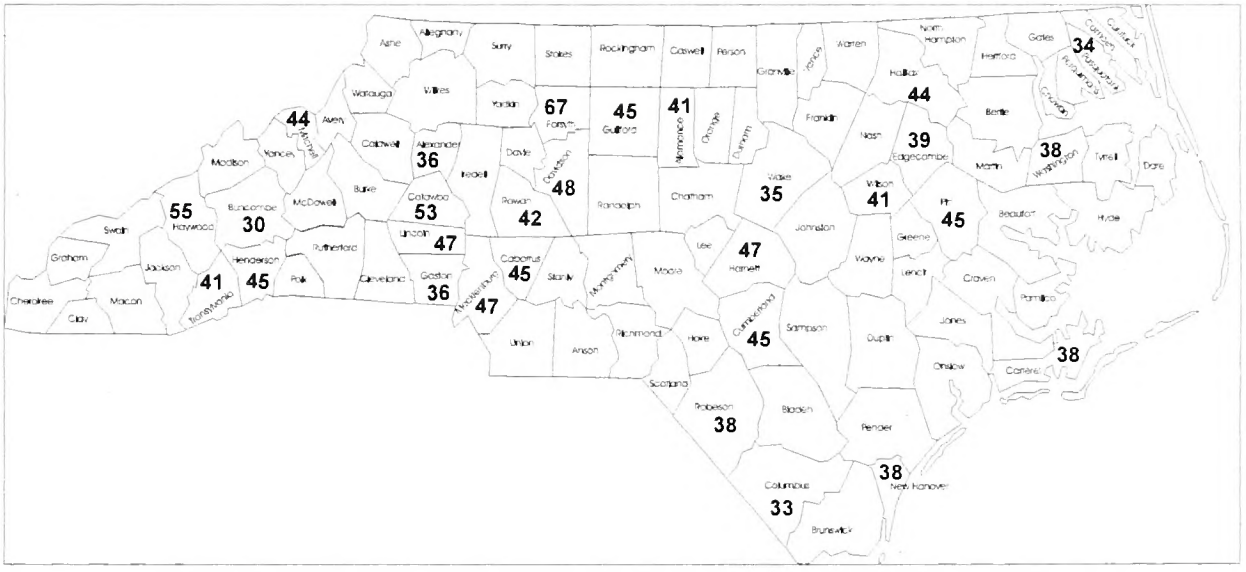


Figure 5.3. Total Suspended Particulates: Maximum Annual Geometric Means, 1991

5.2. PM_{10}

State and local program agencies in North Carolina use high volume samplers and size selective inlets to collect PM_{10} samples. A gravimetric analysis procedure (EPA Reference Method) is used to analyze the samples.

In 1991 21 sites were used to monitor PM_{10} and 1,179 samples were collected. A map of the PM_{10} sampling sites is presented in Figure 5.4, and a detailed summary of the data from each site is given in Table 5.3.

There were no exceedances of the PM_{10} ambient air quality standards in 1991. The greatest 24-hour maximum concentration was 108 $\mu g/m^3$, or about 75% of the standard (150 $\mu g/m^3$). The greatest annual arithmetic mean was 35 $\mu g/m^3$, which is 70% of the standard (50 $\mu g/m^3$).

The second highest 24-hour concentrations are charted by county in Figure 5.5 and the annual arithmetic means are similarly charted in Figure 5.6. (In counties with more than one TSP monitoring site, the concentration reported in Figure 5.5 is the county-wide second maximum 24-hour concentration, and the mean reported in Figure 5.6 is the maximum arithmetic mean for the county.)

Figure 5.4. Location of PM_{10} Monitoring Sites.

Table 5.3. PM-10 in Micrograms Per Cubic Meter ($\mu g/m^3$) For 1991.

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	24 HOUR MAXIMA				ARITH MEAN
		1ST	2ND	3RD	4TH	
BUNCOMBE 37-021-0003 HEALTH & SOCIAL SERVICES BLDG WOODFIN ST ASHEVILLE	58	62	53	45	42	24
CUMBERLAND 37-051-0004 F.S. # 5 3296 VILLAGE DR. FAYETTEVILLE	58	53	52	50	47	27
DURHAM 37-063-0001 HEALTH DEPT 300 E MAIN ST DURHAM	57	54	51	45	44	26
FORSYTH 37-067-0009 HANES HOSIERY PK INDIANA AV & AKRON DR WINSTON-SALEM	60	78	56	53	52	31
FORSYTH 37-067-0013 720 RIDGE AVENUE WINSTON-SALEM	57	80	64	63	60	33
FORSYTH 37-067-0020 SILAS CREEK PKWY AT HAWTHORNE RD WINSTON-SALEM	58	84	55	54	54	31

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	24 HOUR MAXIMA				ARITH MEAN
		1ST	2ND	3RD	4TH	
FORSYTH 37-067-0023 1401 CORPORATION PARKWAY WINSTON-SALEM	58	82	66	65	61	35
FORSYTH 37-067-0024 NORTH FORSYTH HIGH SCHOOL WINSTON-SALEM	43	62	56	52	49	30
FORSYTH 37-067-1001 BODENHEIMER ST KERNERSVILLE	58	71	59	55	51	30
GUILFORD 37-081-0009 EDGEWORTH & BELLEMEADE STS GREENSBORO	58	92	59	56	54	29
HARNETT 37-085-0001 MUNICIPAL BUILDING DUNN	60	58	57	56	53	28
HAYWOOD 37-087-0002 CANTON FIRE DEPT. CANTON	39	60	50	48	47	29
MADISON 37-111-0002 COURTHOUSE MARION	54	100	89	54	49	31

Table 5.3. PM-10 in Micrograms Per Cubic Meter ($\mu g/m^3$) For 1991 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	24 HOUR MAXIMA				ARITH MEAN
		1ST	2ND	3RD	4TH	
MECKLENBURG 37-119-0010 FIRE STA #10 2136 REMOUNT ROAD CHARLOTTE	60	96	59	57	55	31
MECKLENBURG 37-119-1005 400 WESTINGHOUSE BLVD. CHARLOTTE	51	68	61	54	53	32
MITCHELL 37-121-0001 CITY HALL SUMMIT ST SPRUCE PINE	54	108	92	57	55	31
NEW HANOVER 37-129-0005 NINTH AND ORANGE STREETS WILMINGTON	58	58	50	45	45	26
ONSLOW 37-133-0004 2553 ONSLOW DRIVE JACKSONVILLE	60	45	44	41	41	24
PASQUOTANK 37-139-0001 WATER PLANT N WILSON ST ELIZABETH CITY	59	61	59	54	51	25
WAKE 37-183-0003 FIRE STATION #9 SIX FORKS RD NORTH HILLS RALEIGH	60	50	50	49	46	25

Table 5.3. PM-10 in Micrograms Per Cubic Meter ($\mu g/m^3$) For 1991 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	24 HOUR MAXIMA				ARITH MEAN
		1ST	2ND	3RD	4TH	
WAYNE 37-191-0004 HWY 70 WEST PATROL STA. GOLDSBORO	59	55	54	52	48	27
Total Samples	1,179					
Total Sites Sampled	21					

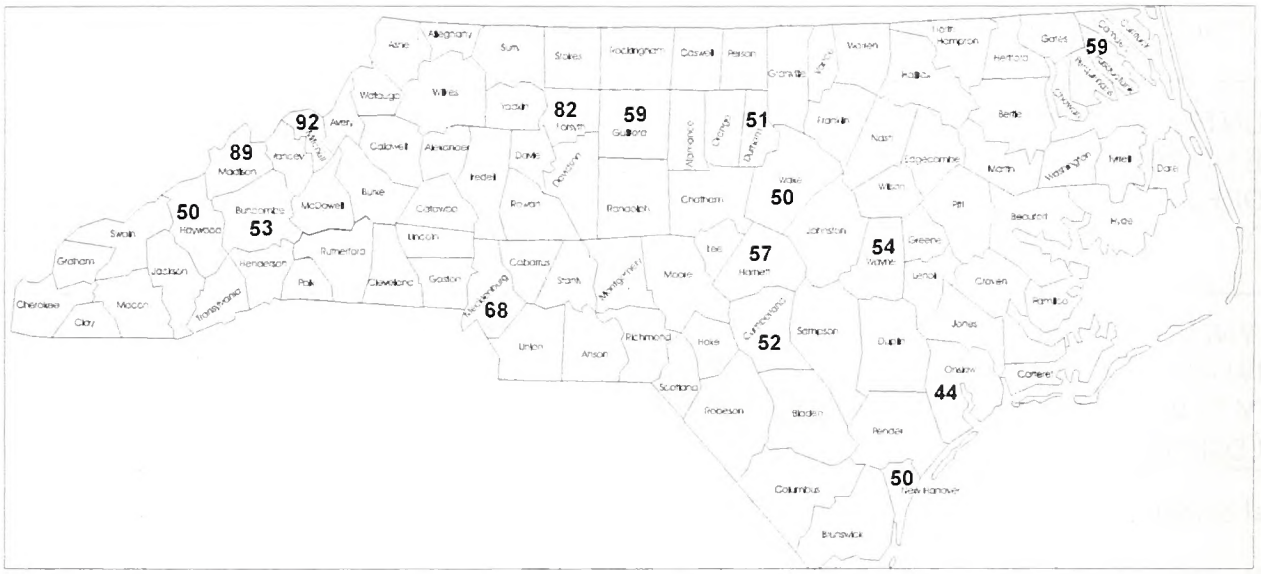


Figure 5.5. PM_{10}: Second Highest 24-Hour Averages, 1991

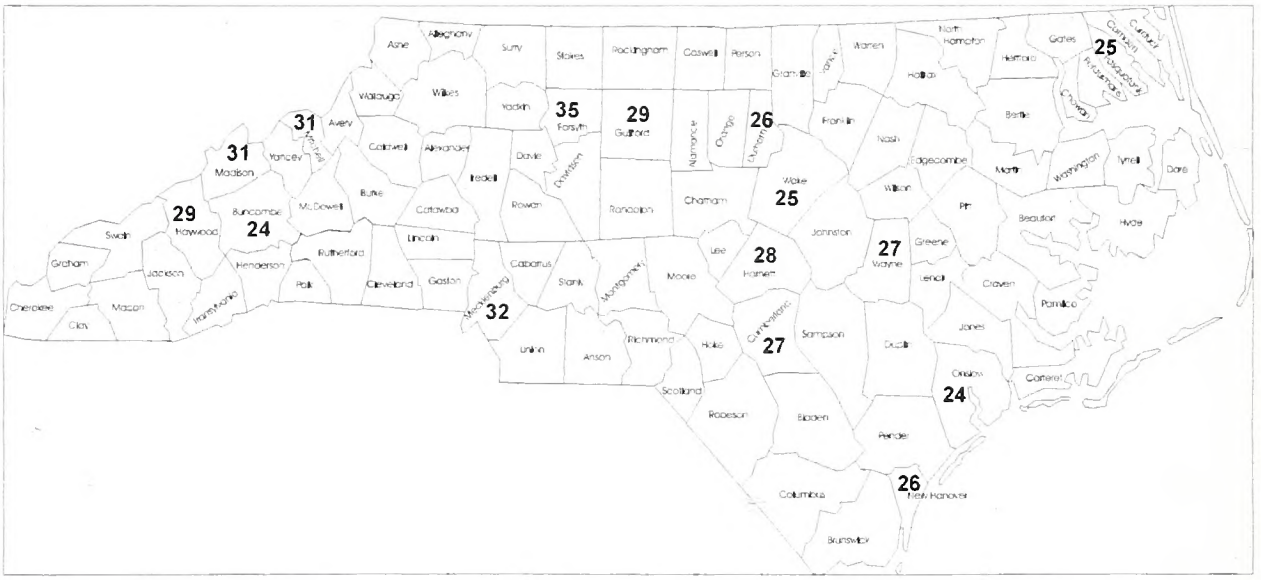


Figure 5.6. PM_{10}: Maximum Annual Arithmetic Means, 1991

5.3. Carbon Monoxide

The North Carolina State agency collects CO data from seven monitors in Fayetteville, Durham, Greensboro and Raleigh, and local program agencies collect CO data from three monitors in Winston-Salem and five monitors in Charlotte using EPA Reference or equivalent methods to measure the concentrations.

In 1991 15 sites were used to monitor CO and 115,441 valid hourly averages were collected. A map of the CO sampling sites is presented in Figure 5.7, and a detailed summary of the data from each site is given in Table 5.4.

There were no exceedances of the CO ambient air quality standards in 1991. The greatest 1-hour average was 15.6 parts per million (ppm), or about 45% of the standard (35 ppm). The greatest 8-hour average was 9.1 ppm, which approximately equals the standard of 9 ppm, but is not a violation of the standard. (In order for the national and State 8-hour standard to be exceeded, the *two* highest reported values for the same monitor must be equal to or greater than 9.5 ppm; the second highest average at the same site not overlapping the 9.1 ppm value was 8.8 ppm.)

The second highest 1-hour concentrations in each county are charted in Figure 5.8 and the second highest 8-hour concentrations are similarly charted in Figure 5.9.

Monthly distributions of 8-hour CO averages are graphed in Figure 5.10 as box-and-whisker plots. (See Appendix C for an explanation of this type of chart.) Historical data have demonstrated that high concentrations of CO occur more frequently in Autumn and Winter than during the warmer months of the year. There are three main reasons for this seasonal variation: (i) North Carolina experiences more atmospheric inversions in colder months, trapping air pollutants at low heights; (ii) motor vehicles emit more CO due to inefficient combustion during cold starts and warm up; and (iii) during colder temperatures, more fuel is burned for comfort heating.

Figure 5.11 identifies areas designated nonattainment under the 1990 Clean Air Act and adjoining areas in which EPA has mandated the wintertime sale of oxygenated gasoline as a control strategy because of the history of exceedances in Forsyth, Durham and Wake Counties. Oxygenated fuel is expected to reduce tailpipe emissions of CO by 25%. However, other factors have also reduced CO concentrations, including increased news media interest and public awareness, and the reporting of the Air Quality Index (see Chapter 6 of this report). As a consequence of increased awareness, more people are keeping their cars in better running condition, thus operating more cleanly; older vehicles are gradually being replaced with newer, more efficient vehicles; and traffic flow improves as new roads are built and better coordinated traffic signals are installed. The motor vehicle Inspection and Maintenance program in effect in Wake County and elsewhere is an intentional control strategy that helps assure cleaner-running cars.

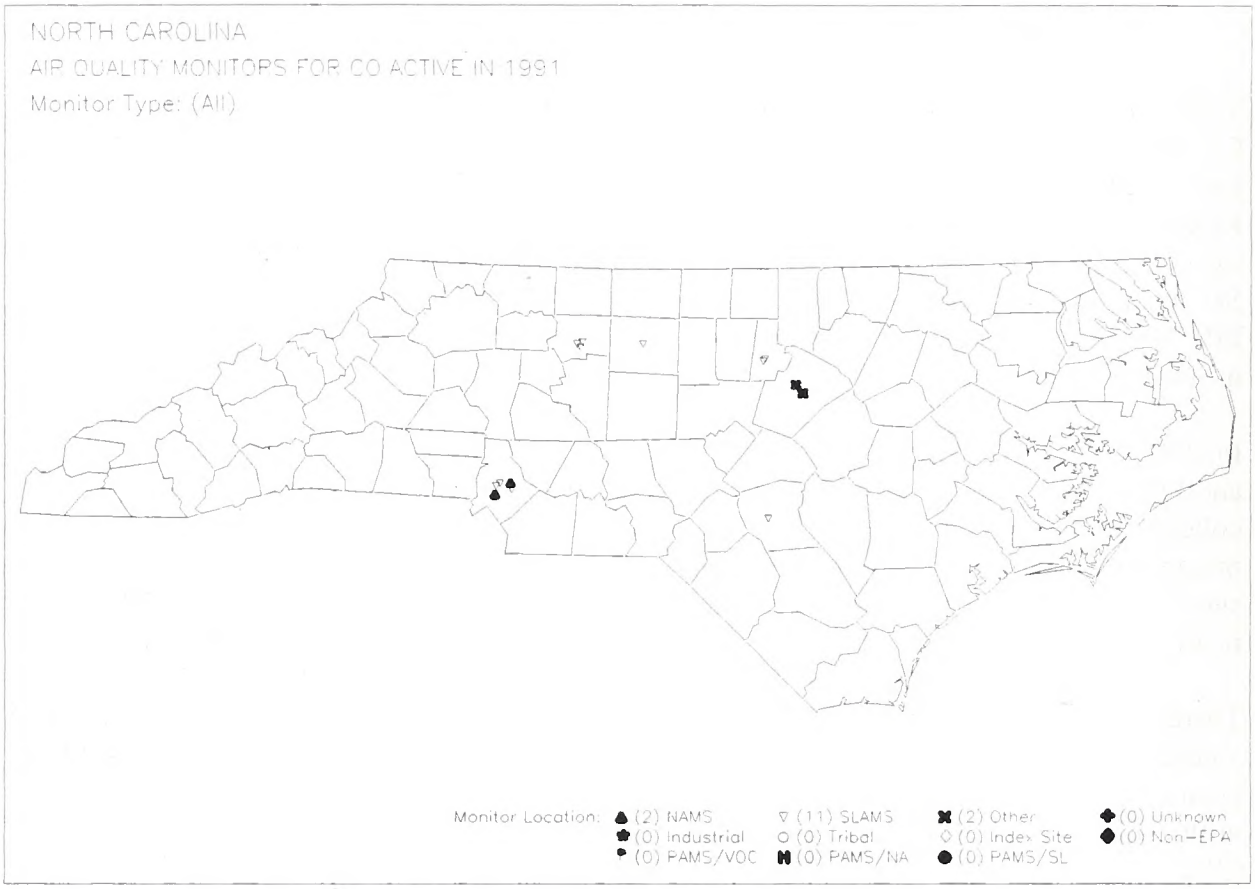


Figure 5.7. Location of Carbon Monoxide Monitoring Sites

Table 5.4. Carbon Monoxide in Parts per Million (Ppm) for 1991

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	1-HOUR MAXIMA		8-HOUR MAXIMA		EXCEEDANCES	
						1-HOUR	8-HOUR
		1ST	2ND	1ST	2ND	#>35	#>9
CUMBERLAND 37-051-0007 CUMBERLAND CO ABC BOARD 1705 OWEN DRIVE FAYETTEVILLE	8706	11.0	9.8	8.2	6.3		
DURHAM 37-063-0008 302 EAST MAIN ST DURHAM	8653	14.4	13.3	8.9	7.1		
DURHAM 37-063-0010 CITY PARK ON UNIVERSITY DRIVE DURHAM	8656	7.3	7.3	5.4	5.0		
FORSYTH 37-067-0018 201 N. MAIN ST. WINSTON-SALEM	7524	8.6	8.4	5.1	4.6		
FORSYTH 37-067-0019 QUEEN STREET AT MILLER PARK WINSTON-SALEM	8599	6.3	5.9	5.1	4.7		
FORSYTH 37-067-0023 1401 CORPORATION PARKWAY WINSTON-SALEM	8677	10.0	9.8	7.1	6.6		

Table 5.4. Carbon Monoxide in Parts per Million (Ppm) for 1991 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	1-HOUR MAXIMA		8-HOUR MAXIMA		EXCEEDANCES	
						1-HOUR	8-HOUR
		1ST	2ND	1ST	2ND	#>35	#>9
GUILFORD 37-081-1011 401 WEST WENDOVER GREENSBORO	8608	8.5	7.7	6.3	5.8		
MECKLENBURG 37-119-0032 5137 CENTRAL AVE. CHARLOTTE	8604	13.6	12.4	8.4	7.3		
MECKLENBURG 37-119-0034 PLAZA ROAD AND LAKEDELL CHARLOTTE	8557	15.6	11.9	7.0	5.9		
MECKLENBURG 37-119-0035 1330 SPRING ST GRNVILLE NEIGHBORHOOD CNT CHARLOTTE	8437	8.9	8.4	6.3	6.3		
MECKLENBURG 37-119-0037 415 EAST WOODLAWN RD CHARLOTTE	8010	9.8	9.7	5.5	4.9		
MECKLENBURG 37-119-0038 301 N TRYON ST CHARLOTTE	8582	11.9	10.4	8.3	7.1		

Table 5.4. Carbon Monoxide In Parts Per Million (PPM) For 1991 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	1-HOUR MAXIMA		8-HOUR MAXIMA		EXCEEDANCES	
						1-HOUR	8-HOUR
		1ST	2ND	1ST	2ND	#>35	#>9
WAKE 37-183-0011 420 S PERSON ST RALEIGH	8641	11.6	11.5	9.1	8.8		1
WAKE 37-183-0013 EF HUTTON, HWY 70 WEST RALEIGH	3740	10.7	9.5	7.9	5.9		
WAKE 37-183-0015 808 NORTH STATE STREET RALEIGH	1447	4.0	3.8	3.3	2.6		
Total Samples	115441						
Total Sites Sampled	15						

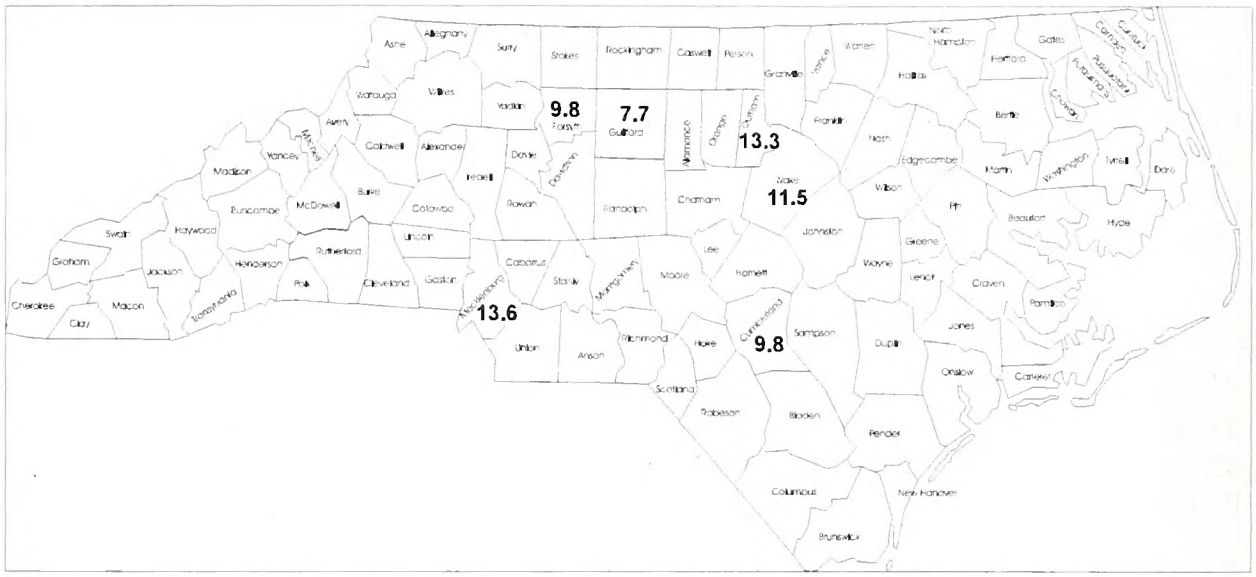


Figure 5.8. Carbon Monoxide: Second Highest One-Hour Average, 1991

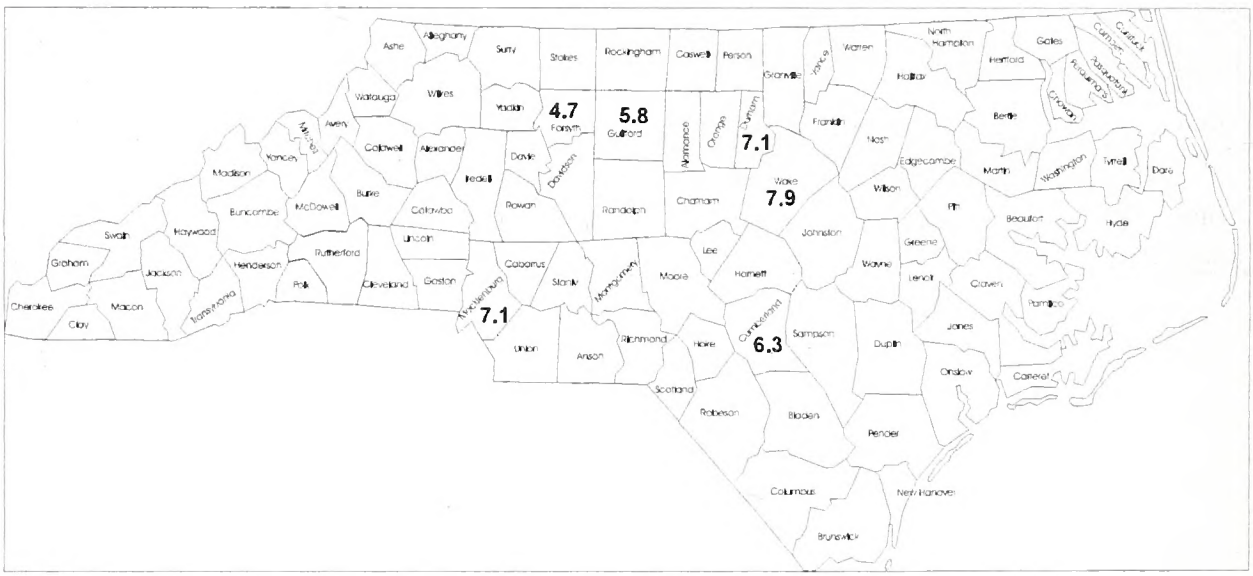


Figure 5.9. Carbon Monoxide: Second Highest Nonoverlapping Eight-Hour Average, 1991

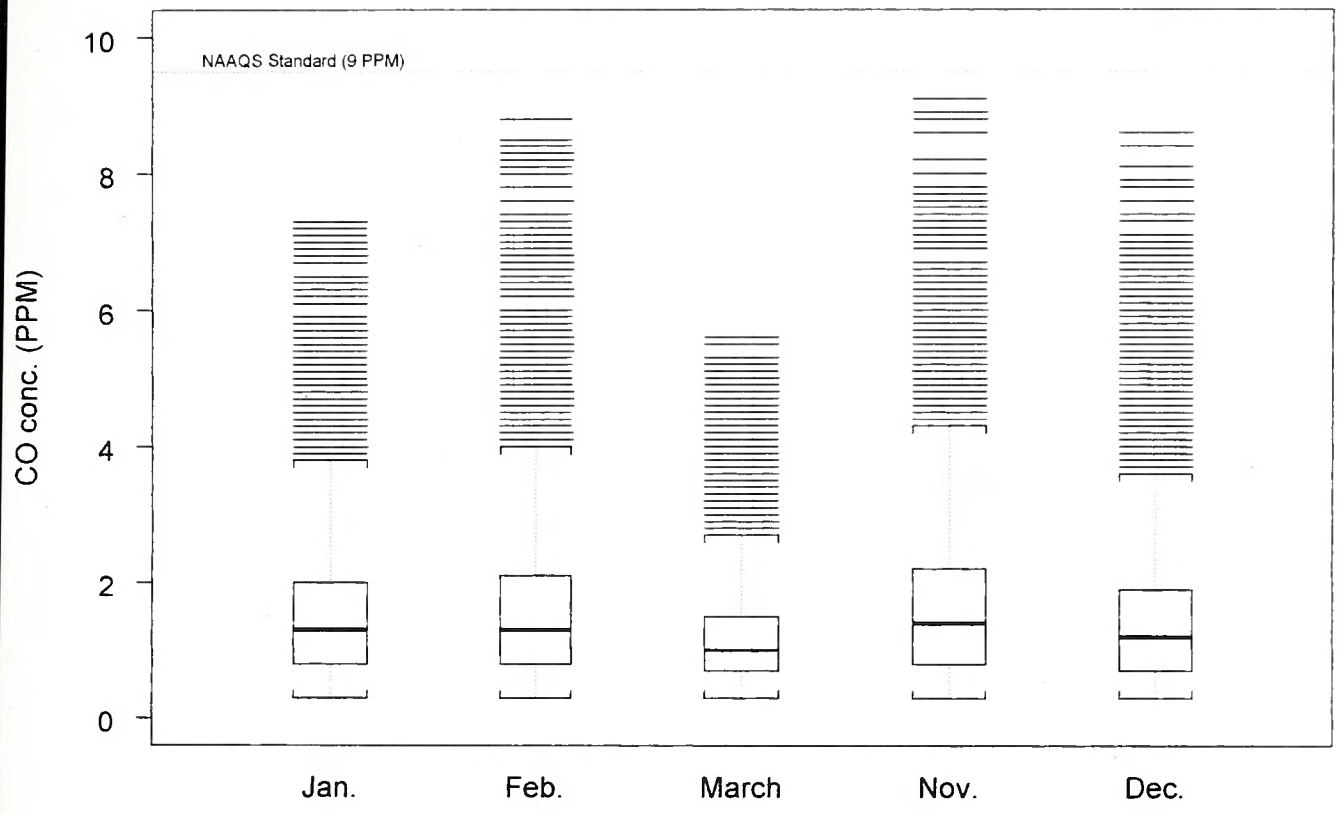


Figure 5.10. Carbon Monoxide: Monthly Distribution of Highest Daily Eight-Hour Averages, 1991

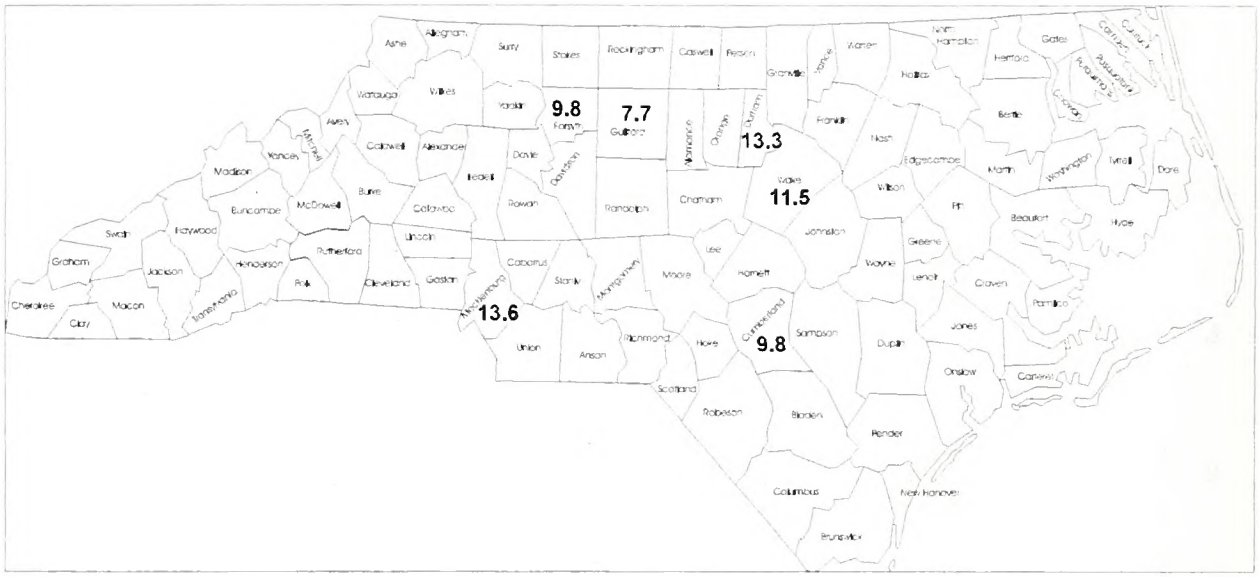


Figure 5.8. Carbon Monoxide: Second Highest One-Hour Average, 1991

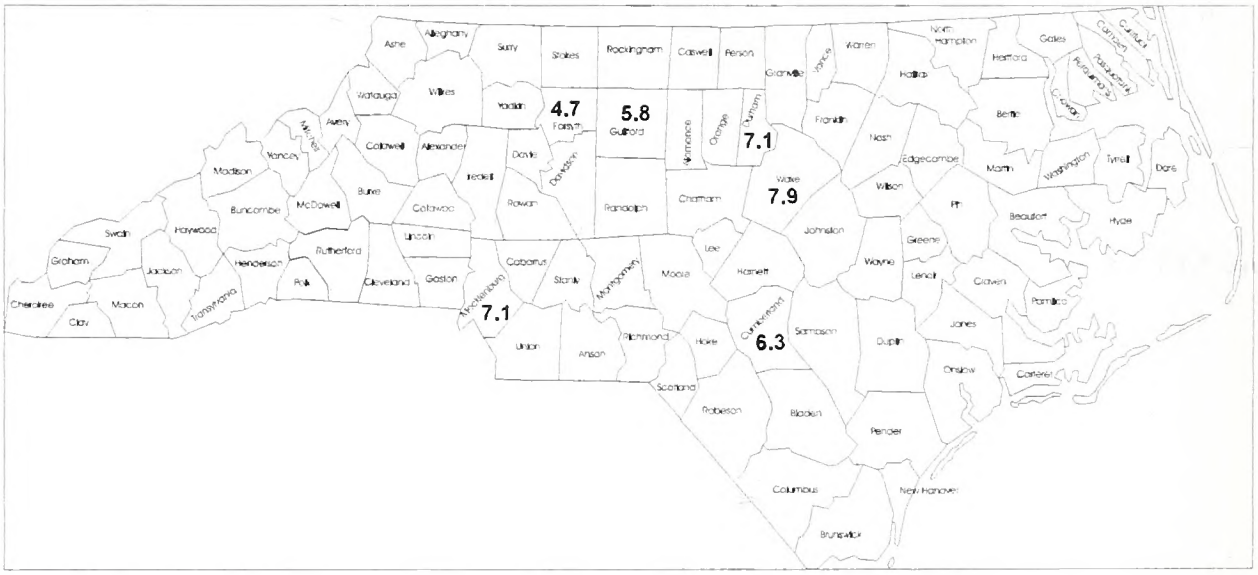


Figure 5.9. Carbon Monoxide: Second Highest Nonoverlapping Eight-Hour Average, 1991

5.4. Ozone

Ozone concentrations are measured using EPA reference or equivalent continuous monitors. Ozone is a seasonal pollutant formed in the atmosphere as a result of many chemical reactions that occur in sunlight mainly during the warmer months. Thus, most ozone monitors do not operate from November through March.

The state and local program agencies operated 23 monitoring sites in 1991 during the Ozone season, April through October. A map of the O_3 sampling sites is presented in Figure 5.12, and a detailed summary of the data from each site is given in Table 5.5. In North Carolina some O_3 sites are operated only one year of every three years, so the monitors considered "active" in 1991 included five sites that were last operated in 1990 and four sites that were last operated in 1989. These 32 active monitoring sites provided 146,671 hourly samples.

There was only one exceedance of the ambient air quality standard for ozone in 1991, at a site in Mecklenburg County. The standard is exceeded when one valid one-hour average exceeds 0.124 ppm at a site and the expected number of exceedances is greater than 1. (To exceed the standard, the largest average must be larger than 0.12 ppm when *rounded* to two significant digits. The "expected number" of exceedances is determined from a 3-year average of exceedance day counts for an area; Mecklenburg County also had 1 exceedance day in 1990 and 3 exceedance days in 1989, thus averaging 1.7 exceedances per year. Moreover, when any ozone sampling day does not have a valid maximum ozone measurement for any reason, the missing day can be counted as an *estimated* exceedance day under certain circumstances [40 CFR 50 App. J, Office of the Federal Register 1993, p. 767-768]. Table 5.5 gives both the actually measured and the estimated number of exceedance days at each site.)

As a consequence of these ozone exceedances, Mecklenburg County has been designated an ozone nonattainment area, and strict hydrocarbon control strategies have been implemented, affecting all the counties in the Charlotte-Gastonia-Rock Hill metropolitan statistical area (Cabarrus, Gaston, Lincoln, Mecklenburg, Rowan and Union Counties, and also York County, South Carolina). A discussion of ozone nonattainment is provided in Appendix D.

The second highest 1-hour concentrations in each county are charted in Figure 5.13 for areas with one or more monitors active in 1989, 1990 or 1991 (using only the latest available year of data).

Figure 5.14 shows the number of "high" ozone values on a monthly basis for the past 3 years, using *all* available data from 1989 through 1991. Monthly distributions of all the 1-hour O_3 data for 1991 are graphed in Figure 5.15 as box-and-whisker plots.

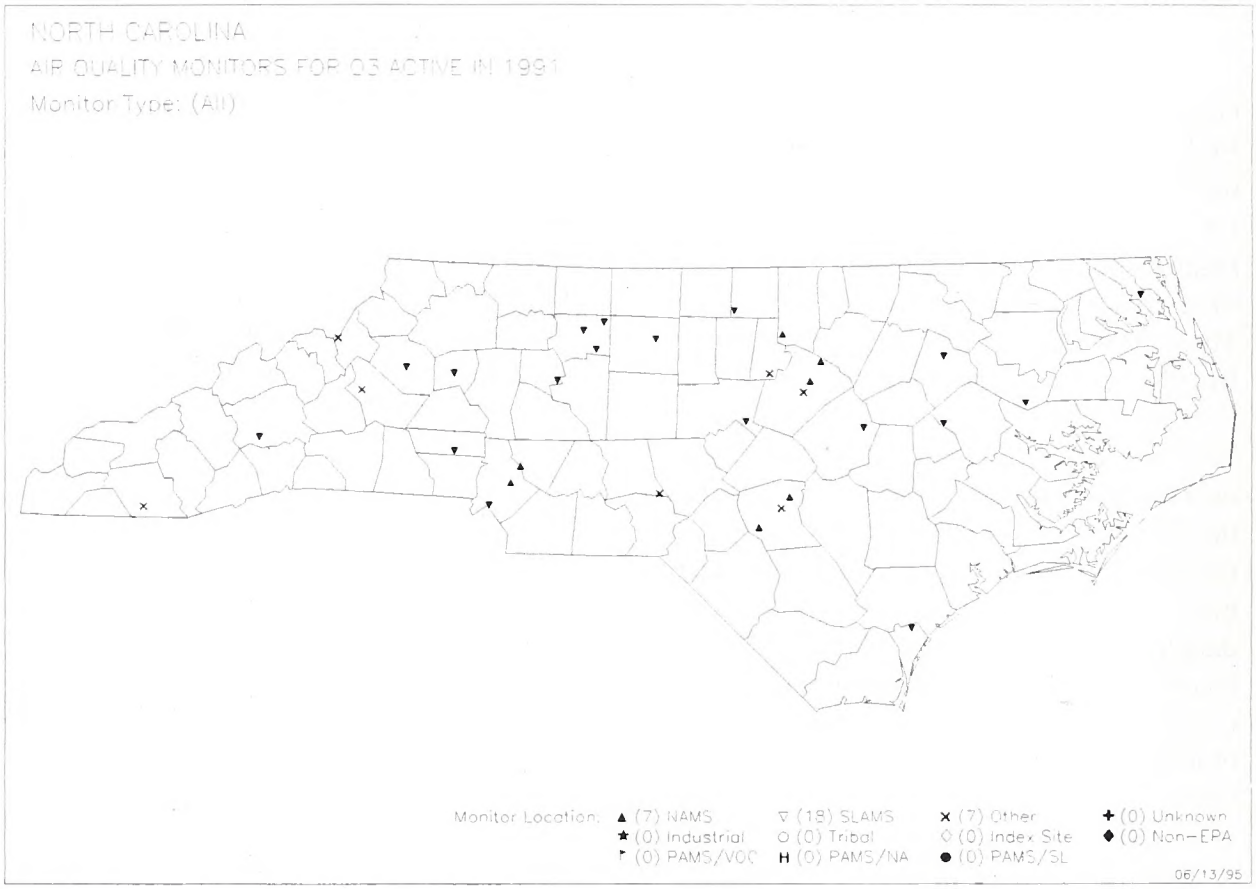


Figure 5.12. Location of Ozone Monitoring Sites.

Table 5.5. Ozone in Parts Per Million for 1991.

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	DAILY 1-HR MAXIMA				VALS>.125	
		1ST	2ND	3RD	4TH	MEAS	EST
1991 Data							
AVERY 37-011-8001 ROARING CREEK RD. PISGAH N.F.	5078	0.095	0.086	0.086	0.082	0	0.00
BUNCOMBE 37-021-0030 ROUTE 191 S BREVARD RD ASHEVILLE	5033	0.089	0.079	0.077	0.075	0	0.00
BURKE 37-023-0004 126 AND 1254 MORGANTON	3111	0.090	0.075	0.072	0.072	0	0.00
CALDWELL 37-027-0003 HWY 321 N LENOIR	4809	0.096	0.093	0.085	0.084	0	0.00
CUMBERLAND 37-051-0001 OLD US HWY 301 @ ARMSTRONG JR HIGH EASTOVER	3018	0.101	0.101	0.100	0.099	0	0.00
CUMBERLAND 37-051-0008 1/4MI SR1857/US301/1857	4856	0.106	0.101	0.100	0.089	0	0.00
CUMBERLAND 37-051-1002 HOPE MILLS POLICE DPT ROCKFISH RD. FAYETTEVILLE	4662	0.096	0.090	0.089	0.089	0	0.00

Table 5.5. Ozone in Parts Per Million for 1991 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	DAILY 1-HR MAXIMA				VALS>.125	
		1ST	2ND	3RD	4TH	MEAS	EST
DAVIE 37-059-0099 FORK RECREATION CENTER FORK	4843	0.101	0.093	0.093	0.092	0	0.00
FORSYTH 37-067-0006 GOODWILL CHURCH RD AT VOL FIRE DEPT. WINSTON-SALEM	4879	0.100	0.099	0.098	0.094	0	0.00
FORSYTH 37-067-0007 5337 OLD RURAL HALL ROAD WINSTON-SALEM	4974	0.116	0.107	0.102	0.097	0	0.00
FORSYTH 37-067-1008 3656 PIEDMONT MEMORIAL DRIVE WINSTON-SALEM	4877	0.100	0.097	0.095	0.094	0	0.00
GRANVILLE 37-077-0001 WATER TREATMENT PLANT JOHN UMSTEAD HOSP BUTNER	4780	0.111	0.105	0.105	0.103	0	0.00
GUILFORD 37-081-0011 KEELY PARK KEELY RD MCCLEANSVILLE	4675	0.114	0.106	0.103	0.102	0	0.00
LINCOLN 37-109-0099 SR 1315 & SR 1313 IRON STATION	4804	0.091	0.089	0.088	0.087	0	0.00

Table 5.5. Ozone in Parts Per Million for 1991 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	DAILY 1-HR MAXIMA				VALS>.125	
		1ST	2ND	3RD	4TH	MEAS	EST
MADISON 37-113-8001 COWEETA HYDROLOGIC LABORATORY	5002	0.086	0.086	0.082	0.072	0	0.00
MECKLENBURG 37-119-0034 PLAZA ROAD AND LAKEDELL CHARLOTTE	4632	0.124	0.115	0.114	0.108	0	0.00
MECKLENBURG 37-119-1005 400 WESTINGHOUSE BLVD. CHARLOTTE	4982	0.130	0.119	0.116	0.116	1	1.00
MECKLENBURG 37-119-1009 29 N@ MECKLENBURG CAB CO CHARLOTTE	4815	0.121	0.111	0.110	0.104	0	0.00
MONTGOMERY 37-123-0099 SANDHILLS RESEARCH STATION	5029	0.118	0.102	0.086	0.082	0	0.00
PITT 37-147-0099 US 264 NEAR WATER TOWER FARMVILLE	4794	0.099	0.091	0.091	0.091	0	0.00
WAKE 37-183-0014 E MILLBROOK JR HI 3801 SPRING FOREST RD RALEIGH	4804	0.108	0.107	0.105	0.103	0	0.00

Table 5.5. Ozone in Parts Per Million for 1991 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	DAILY 1-HR MAXIMA				VALS>.125	
		1ST	2ND	3RD	4TH	MEAS	EST
WAKE 37-183-0015 808 NORTH STATE STREET RALEIGH	795	0.087	0.085	0.072	0.067	0	0.00
WAKE 37-183-2001 HWY 98 WATER TREATMENT PLAN WAKE FOREST	4835	0.116	0.108	0.102	0.098	0	0.00
Total Samples	104,087						
Total Sites Sampled	23						
1990 Data							
ALEXANDER 37-003-0003 STATE ROAD 1177 TAYLORSVILLE	4869	0.094	0.092	0.091	0.090	0	0.00
CAMDEN 37-029-0099 COUNTY ROAD 1136 & 1134 CAMDEN	4680	0.102	0.102	0.096	0.096	0	0.00
EDGECOMBE 37-065-0099 RT 2, BOX 195 TARBORO	4856	0.097	0.097	0.096	0.095	0	0.00
JOHNSTON 37-101-0099 HIGHWAY 301 & SR 2141 MICRO	4797	0.099	0.096	0.095	0.094	0	0.00
NEW HANOVER 37-129-0002 6028 HOLLY SHELTER RD CASTLE HAYNE	4484	0.102	0.093	0.092	0.092	0	0.00

Table 5.5. Ozone in Parts Per Million for 1991 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	DAILY 1-HR MAXIMA				VALS> 125	
		1ST	2ND	3RD	4TH	MEAS	EST
Total Samples	23,709						
Total Sites	5						
1989 Data							
CHATHAM 37-037-0098 MONCURE PLANT - SOUTH SITE MONCURE	4593	0.096	0.092	0.089	0.089	0	0.00
DURHAM 37-063-8001 ALEXANDER DR., N. OF HIGHWAY 54 DURHAM	4902	0.121	0.115	0.104	0.096	0	0.00
MCDOWELL 37-117-0099 SR 1538 NC 171 FARMLIFE	4769	0.087	0.086	0.086	0.083	0	0.00
PERSON 37-145-0099 SR 1102 & NC 49 GORDONTON	4634	0.089	0.088	0.087	0.084	0	0.00
Total Samples	18,903						
Total Sites	4						

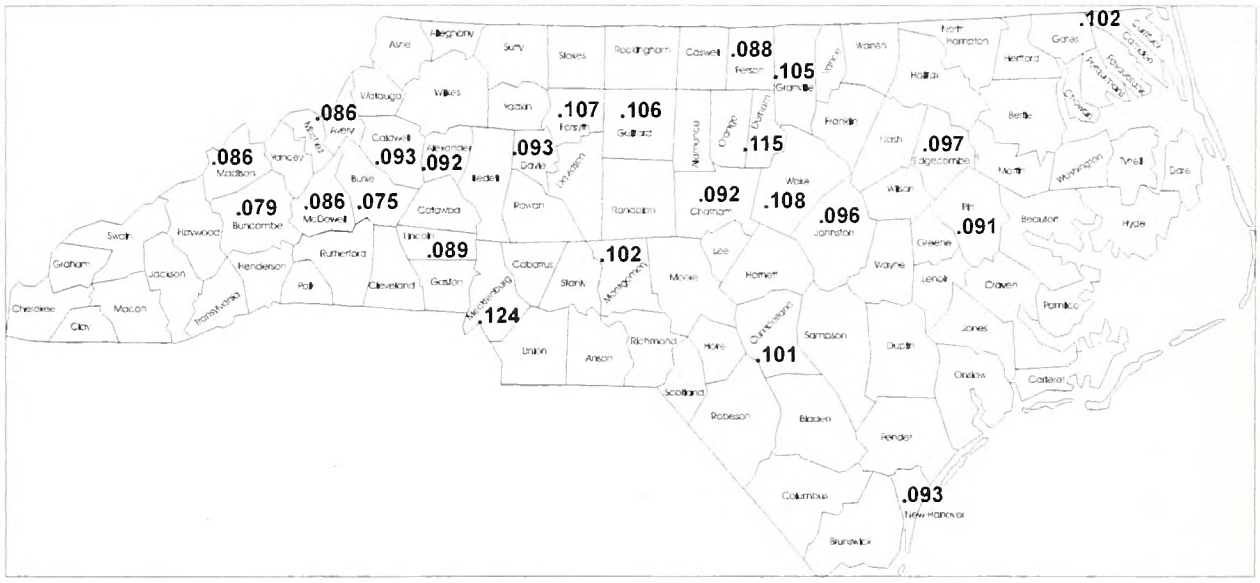


Figure 5.13. Ozone: Second Highest Annual One-Hour Average in the most recent year of data, from 1989, 1990 or 1991

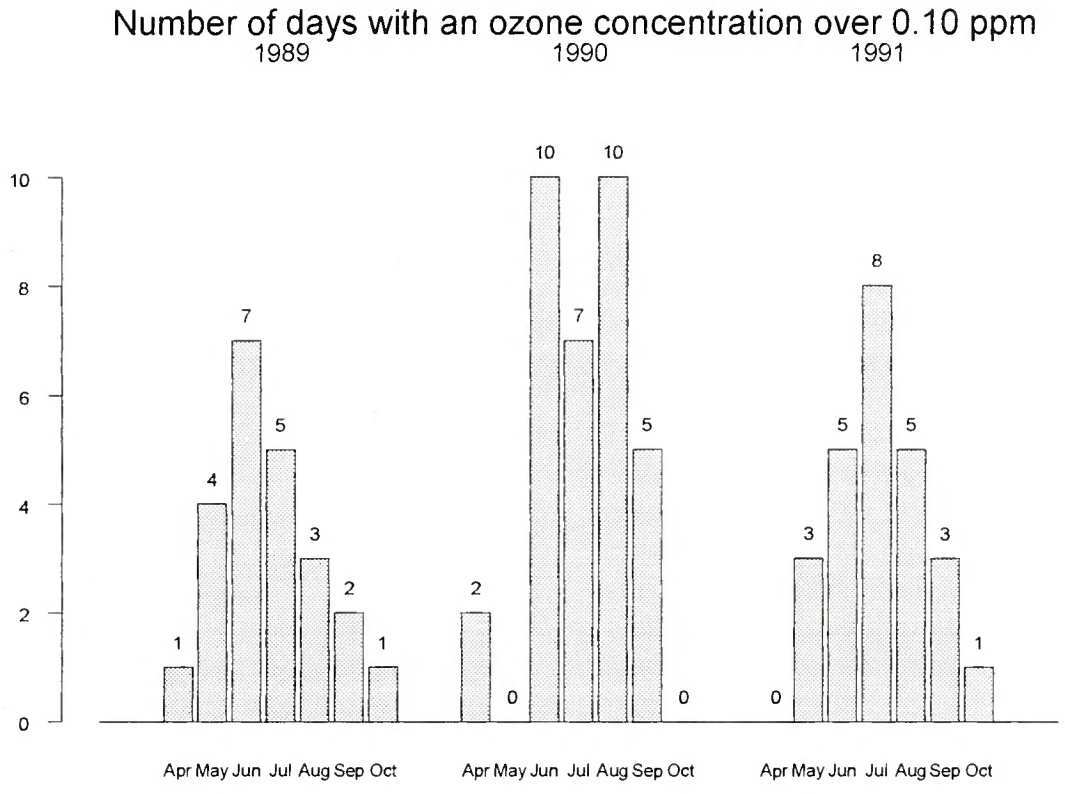


Figure 5.14. Number of Days with 1-Hour Ozone Averages in Excess of 0.10 ppm, 1989-91 based on all sites operated each year

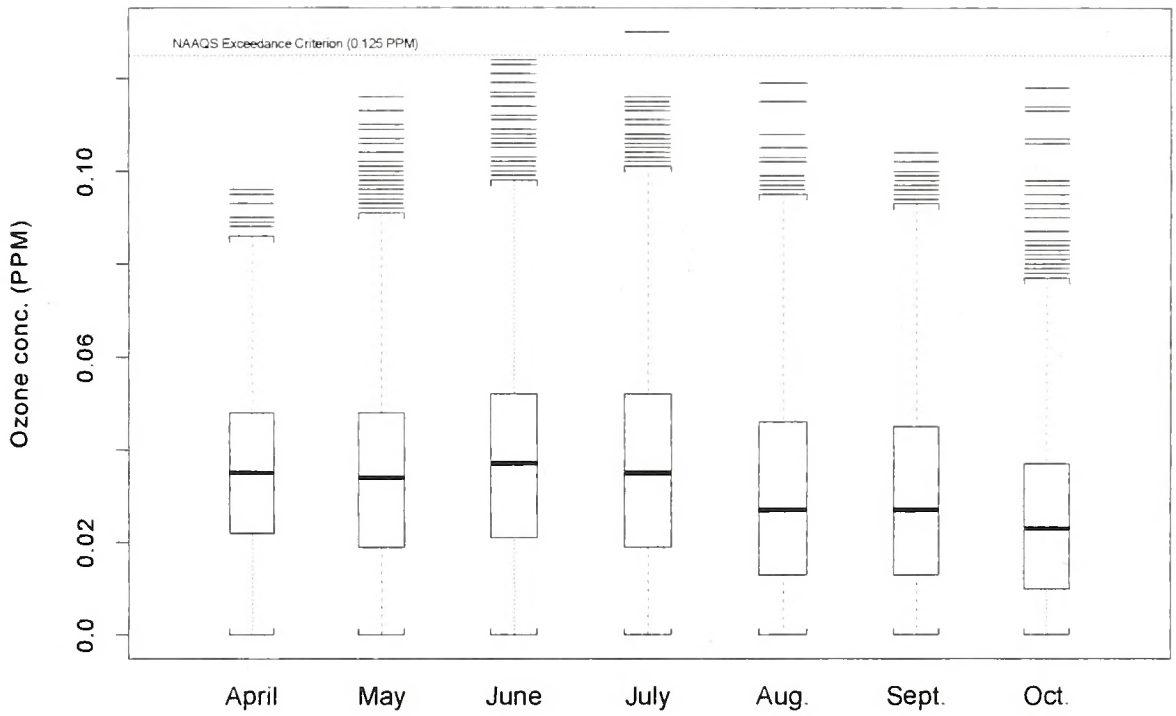


Figure 5.15. Monthly Distributions of ozone measurements, 1991

5.5. Sulfur Dioxide

Sulfur dioxide (SO_2) concentrations were measured by the state and two local program agencies using EPA reference or equivalent methods. Fifteen SO_2 monitors were active in North Carolina in 1991. However, some SO_2 sites are operated only one year of every three years, so ten sites provided data *in* 1991, four sites provided data in 1990 (and will next be operated in 1993), and one site provided data in 1989 (and will next be operated in 1992). Because of the overlapping time frame, summary data collected in 1990 from two monitors that were permanently discontinued in 1990 are also included in this report.

From the 17 sites with SO_2 data obtained between 1989 and 1991, 94,930 valid hourly averages were collected. A map of the (15 "active") SO_2 sampling sites is presented in Figure 5.16, and a detailed summary of the data from each site is given in Table 5.6.

There were no exceedances of the SO_2 ambient air quality standards in 1991. The greatest annual arithmetic mean was 19 $\mu g/m^3$, or about 25% of the standard (80 $\mu g/m^3$), the greatest maximum 24-hour average was 92 $\mu g/m^3$, about 25% of the standard (365 $\mu g/m^3$), and the greatest maximum 3-hour average was 389 $\mu g/m^3$, about 30% of the welfare-related (secondary) standard.
It appears that the size of an urban area has little effect on the ambient concentrations of SO_2 in North Carolina. Seasonal variations, such as are present with CO and O_3, do not appear to exist for SO_2. Major source characteristics such as type, size, distribution, control devices, operating conditions and dispersion situations significantly affect the amount of SO_2 present in ambient air.

The second highest three-hour concentrations in each county are charted in Figure 5.17. The second highest 24-hour concentrations in each county are charted in Figure 5.18.

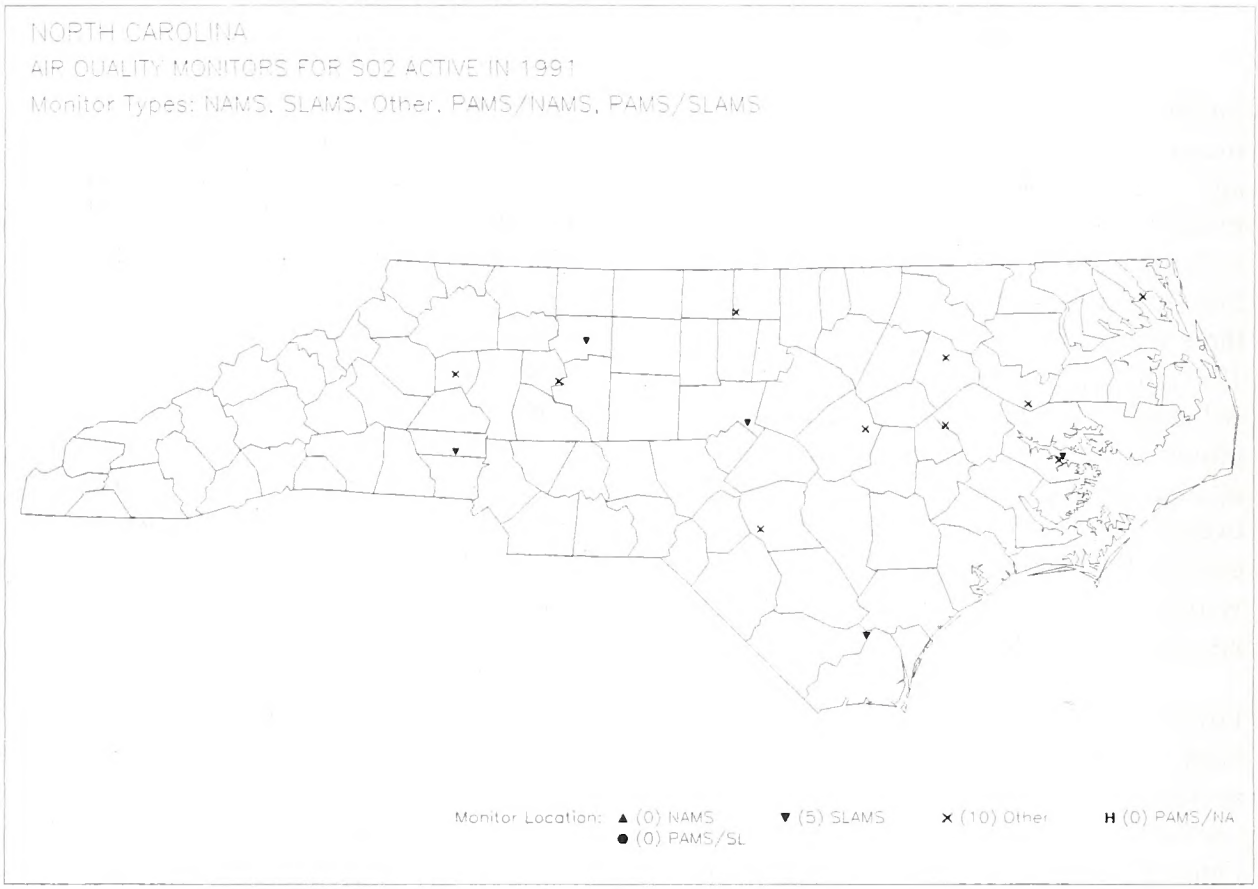


Figure 5.16. Location of Sulfur Dioxide Monitoring Sites.

Table 5.6. Most Recent Sulfur Dioxide Data in Micrograms Per Cubic Meter ($\mu g/m^3$) From All Sites for 1989-91.

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	MAX 1-HR		MAX 3-HR		MAX 24-HR		ARITH MEAN
		1ST	2ND	1ST	2ND	1ST	2ND	
1991 Data								
BEAUFORT 37-013-0003 NC HIGHWAY 306 AURORA	3767	176	174	129	105	50	28	7.7
BEAUFORT 37-013-0004 PAMLICO RIVER SOUTH FERRY LANDING AURORA	4329	234	157	110	97	27	23	6.5
CAMDEN 37-029-0099 COUNTY ROAD 1136 & 1134 CAMDEN	1125	93	64	72	47	34	24	8.1
CHATHAM 37-037-0098 MONCURE PLANT - SOUTH SITE MONCURE	343	213	119	98	83	38	25	12.3
COLUMBUS 37-047-0001 ACME-DELCO SAMPLING SITE HWY 87 ACME-DELCO	8090	876	391	327	143	75	44	12.1
DAVIE 37-059-0099 FORK RECREATION CENTER FORK	8017	245	171	148	138	73	52	9.9

Table 5.6. Most Recent Sulfur Dioxide Data in Micrograms Per Cubic Meter ($\mu g/m^3$) From All Sites for 1989-91 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	MAX 1-HR		MAX 3-HR		MAX 24-HR		ARITH MEAN
		1ST	2ND	1ST	2ND	1ST	2ND	
FORSYTH 37-067-0022 1300 BLK. HATTIE AVENUE WINSTON-SALEM	8508	447	381	389	191	92	72	17.6
LINCOLN 37-109-0099 SR 1315 & SR 1313 IRON STATION	8241	221	217	122	115	42	39	8.7
MCDOWELL 37-117-0099 SR 1538 NC 171 FARMLIFE	442	63	54	53	40	23	16	8.2
PITT 37-147-0099 US 264 NEAR FARMVILLE WATER TOWER FARMVILLE	8211	83	63	47	47	30	28	7.4
Total Samples	51,073							
Total Sites Sampled	10							
1990 Data								
ALEXANDER 37-003-0003 STATE ROAD 1177 TAYLORSVILLE	8169	93	73	65	55	30	27	6.9
CUMBERLAND 37-051-1002 HOPE MILLS POLICE DPT. ROCKFISH RD. FAYETTEVILLE	8300	92	88	66	62	31	31	8.1

Table 5.6. Most Recent Sulfur Dioxide Data in Micrograms Per Cubic Meter ($\mu g/m^3$) From All Sites for 1989-91 (Continued).

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	MAX 1-HR		MAX 3-HR		MAX 24-HR		ARITH MEAN
		1ST	2ND	1ST	2ND	1ST	2ND	
EDGECOMBE 37-065-0099 RT 2, BOX 195 TARBORO, NC LEGGETT	8175	156	130	138	93	48	25	6.9
FORSYTH 37-067-0007 5337 OLD RURAL HALL ROAD WINSTON-SALEM[d]	3061	310	181	144	127	60	55	19.0
GUILFORD 37-081-0010 1305 MERRITT DR. GREENSBORO[e]	341	87	68	58	47	24	23	14.7
JOHNSTON 37-101-0099 HIGHWAY 301 & SR 2141 MICRO	8152	58	56	53	52	29	20	6.7
Total Samples	36,208							
Total Sites Sampled	6							
1989 Data								
PERSON 37-145-0099 SR 1102 & NC 49 GORDONTON	7659	230	211	166	157	72	58	10.2 90

[d]This site was permanently discontinued in May, 1990.

[e]This site was permanently discontinued in January, 1990.

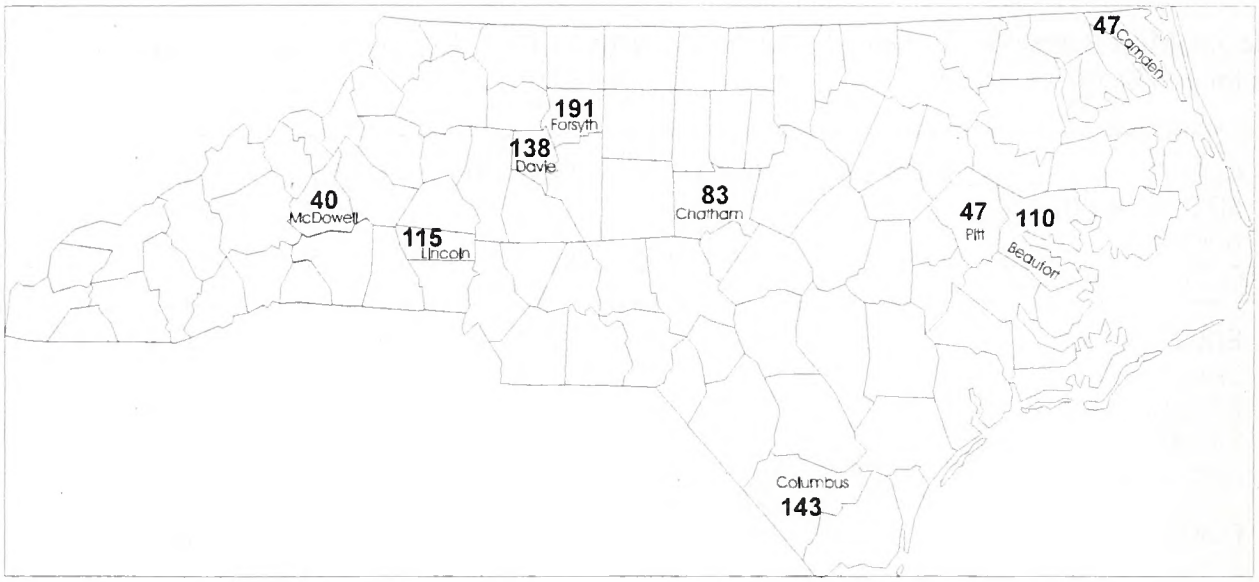


Figure 5.17. SO_2: Second Highest 3-Hour Averages, 1991

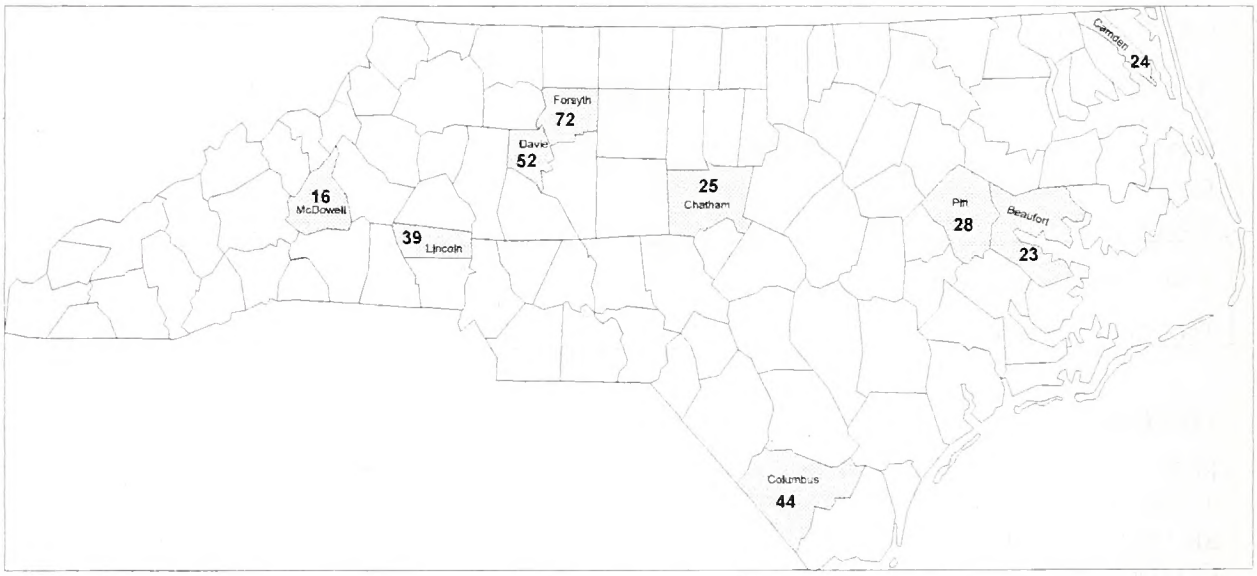


Figure 5.18. SO_2: Second Highest 24-Hour Averages, 1991

5.6. Nitrogen Dioxide

Nitrogen dioxide (NO_2) concentrations were measured using EPA reference or equivalent continuous monitors in 1991 at two state program sites in Wake County, one local program site in Forsyth County, and one local program site in Mecklenburg County.

From these four sites, 26,803 hourly NO_2 measurements were reported. A map of the four NO_2 sampling sites is presented in Figure 5.19, and a summary of the 1991 NO_2 data is given in Table 5.7. Figure 5.20 shows a box-and-whisker plot showing the distribution of hourly average concentrations compared to the annual arithmetic mean standard of 0.053 ppm. Each site has only one or two outlying high sample values that are above the standard defined for the arithmetic mean; the arithmetic means (Table 5.7) are about 30% of the standard.

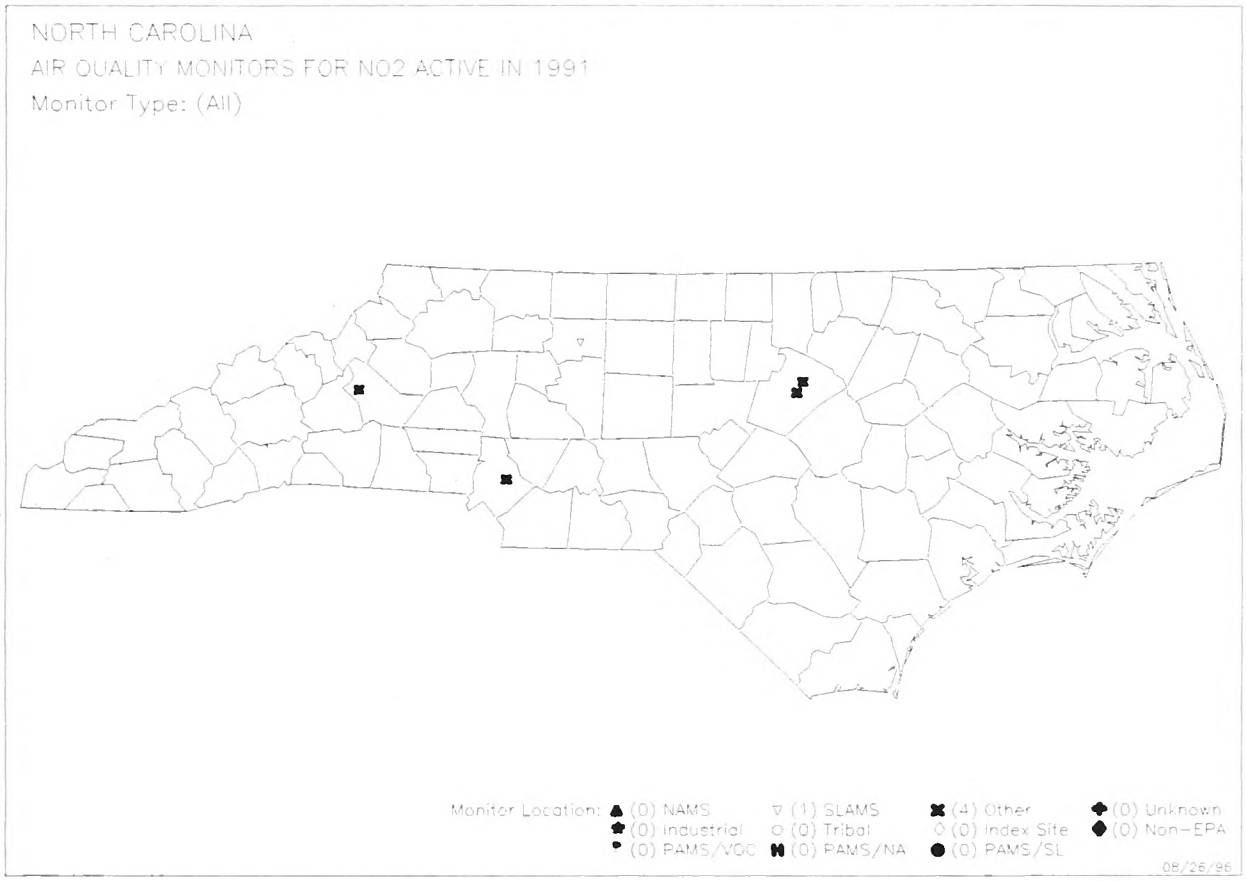


Figure 5.19. Location of Nitrogen Dioxide Monitoring Sites

Table 5.7. Nitrogen Dioxide in Parts Per Million (PPM) For 1991

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	MAX 1-HOUR 1ST	 2ND	ARITH MEAN
FORSYTH 37-067-0022 1300 BLK. HATTIE AVENUE WINSTON-SALEM	8375	0.069	0.068	0.016
MECKLENBURG 37-119-0034 PLAZA ROAD AND LAKEDELL CHARLOTTE	8276	0.088	0.081	0.016
WAKE 37-183-0014 E MILLBROOK JR HIGH 3801 SPRING FOREST RD RALEIGH	5561	0.067	0.066	0.012
WAKE 37-183-0015 808 NORTH STATE STREET RALEIGH	4591	0.091	0.088	0.016
Total Samples	26803			
Total Sites Sampled	4			

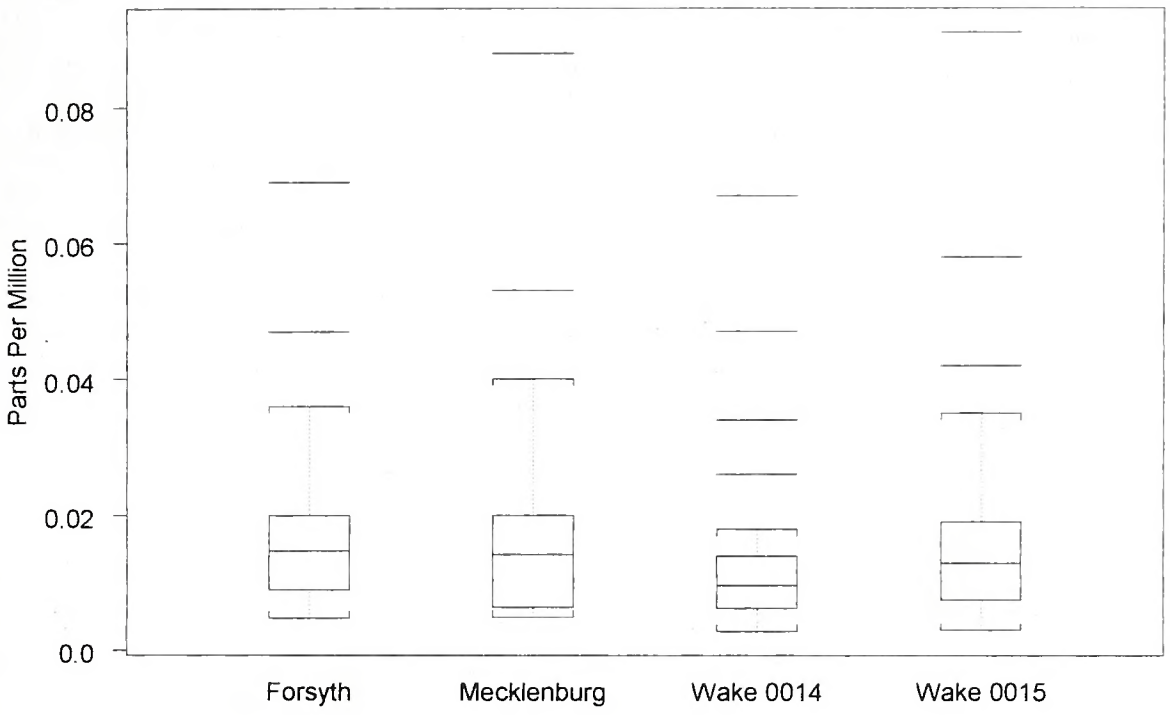


Figure 5.20. Distributions of Nitrogen Dioxide Concentrations, 1991

5.7. Lead

The state and local program agencies have not performed routine analysis of ambient lead (Pb) in North Carolina since 1982. Lead monitoring was discontinued as a result of the low values measured and a continuing decrease in the lead concentrations being reported. Ambient Pb concentrations in 1982 were approximately one-half the concentrations observed in 1979. The decrease in ambient Pb concentrations is due to the reduction and elimination of leaded gasoline, resulting in greatly reduced lead emissions from automobiles.

The state and local agencies provide particulate filter samples from five sites to EPA. EPA performs lead analysis on these filters as part of the National Particulate Analysis program (formerly the National Filter Analysis Network, NFAN). The most recent year of data available is 1990; no data have been provided for 1991. Lead concentrations in 1990 average less than half the concentrations measured in 1987 and less than 1/10 of the concentrations measured in 1982. The greatest quarterly lead concentration in 1990 in North Carolina was 0.08 $\mu g/m^3$, which is about five percent of the standard.

Summaries of the lead data from 1988 and 1990 are given in Table 5.8 and Table 5.9. The 1988 data have not been published in a previous Annual Report.

Table 5.8. Lead in Micrograms Per Cubic Meter ($\mu g/m^3$) For 1988

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	QUARTERLY ARITHMETIC MEANS				MEANS >1.5
		1ST	2ND	3RD	4TH	
DURHAM 37-063-0001 300 EAST MAIN ST DURHAM	10		0.03	0.03		0
FORSYTH 37-067-0001 SIXTH AND BROAD ST WINSTON-SALEM	8	0.02	0.01	0.00	0.02	0
GUILFORD 37-081-0009 EDGEWORTH AND BELLEMEADE ST GREENSBORO	9		0.03	0.03		0
MECKLENBURG 37-119-0001 600 EAST TRADE ST CHARLOTTE	13	0.03	0.04			0
WAKE 37-183-0003 FIRE STATION #9 NORTH HILLS PLAZA RALEIGH	10		0.02	0.02		0
Total Samples	50					
Total Sites Sampled	5					

Table 5.9. Lead in Micrograms Per Cubic Meter (μg/m³) For 1990.

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	QUARTERLY ARITHMETIC MEANS				MEANS >1.5
		1ST	2ND	3RD	4TH	
DURHAM 37-063-0001 300 EAST MAIN ST DURHAM	4	0.02	0.01	0.00	0.02	0
FORSYTH 37-067-0001 SIXTH AND BROAD ST WINSTON-SALEM	4	0.01	0.01	0.00	0.01	0
GUILFORD 37-081-0009 EDGEWORTH AND BELLEMEADE ST GREENSBORO	3	0.02	0.01	0.01		0
MECKLENBURG 37-119-0001 600 EAST TRADE ST CHARLOTTE	4	0.03	0.08	0.05	0.03	0
WAKE 37-183-0003 FIRE STATION #9 NORTH HILLS PLAZA RALEIGH	2		0.00	0.01		0
Total Samples	17					
Total Sites Sampled	5					

6. Air Quality Index

The Air Quality Index (AQI) was developed by the EPA to provide the public with a simple, accessible, uniform assessment of air quality at a specific location, based on the criteria pollutants PM_{10}, CO, O_3, SO_2 and NO_2. AQI measurements are made and reported in all U.S. metropolitan areas with a population of over 200,000. Ambient concentrations of each of these five pollutants is converted to a segmented linear numerical scale ranging from 0 to 500, where 100 corresponds to the EPA primary standard for a 24-hour average (8-hour CO average, 1-hour O_3 average) and 500 corresponds to a concentration associated with "significant harm". The AQI is determined by the pollutant with the highest scaled concentration, and a subjective description of "good", "moderate", "unhealthful, "very unhealthful", or "hazardous" is included with the report, with the descriptions corresponding to AQI values of 0-50, 51-100, 101-200, 201-300, and 301-500, respectively. For AQI values between 101 and 500, an appropriate cautionary statement is included advising people susceptible to deleterious health effects to restrict activities and exposure to the ambient air.

An AQI of 101-200 (unhealthful) can produce mild aggravation of symptoms in susceptible persons and possible irritation in healthy persons. People with existing heart or lung ailments should reduce physical exertion and outdoor activity. The general population should reduce vigorous outdoor activity.

An AQI of 201 to 300 (very unhealthful) can produce significant aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease, and a variety of symptoms in healthy persons. Elderly people and those with existing heart or lung disease should stay indoors and reduce physical activity. The general population should avoid vigorous outdoor activity.

The health effects of an AQI of over 300 (hazardous) include early onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons. The elderly and persons with existing diseases should stay indoors and avoid physical exertion.

At AQI values over 400, premature death of ill and elderly persons may result, and healthy people will experience adverse symptoms that affect normal activity. Outdoor activity should be avoided. All people should remain indoors, keeping windows and doors closed, and should mimimize physical exertion.

During winter months in North Carolina, carbon monoxide usually has the highest pollution standard index value, and in summer months the highest index value is usually due to ozone.

In North Carolina, four areas provide an AQI report to the public by telephone *via* computer-generated recorded voice announcements 24

hours daily. The AQI report may also be published by local newspapers or broadcast on radio and television stations. Air Quality Index telephone numbers in North Carolina are as follows:

Charlotte 704-333-SMOG (704-333-7664)
Durham 919-733-DATA (919-733-3282)
Fayetteville . . . 919-486-9413
Raleigh 919-733-DATA (919-733-3282)

[As of the publication date of this report, the telephone numbers given above for Durham, Fayetteville and Raleigh have been discontinued. These areas are now included in a new statewide multi-area Air Quality Index. The new telephone number is 888-AIR-WISE (888-247-9473) and is a toll-free call from anywhere in North Carolina.]

Air Quality Index values for 1991 at four metropolitan areas in North Carolina are given in Figures 6.1, 6.2, 6.3 and 6.4.

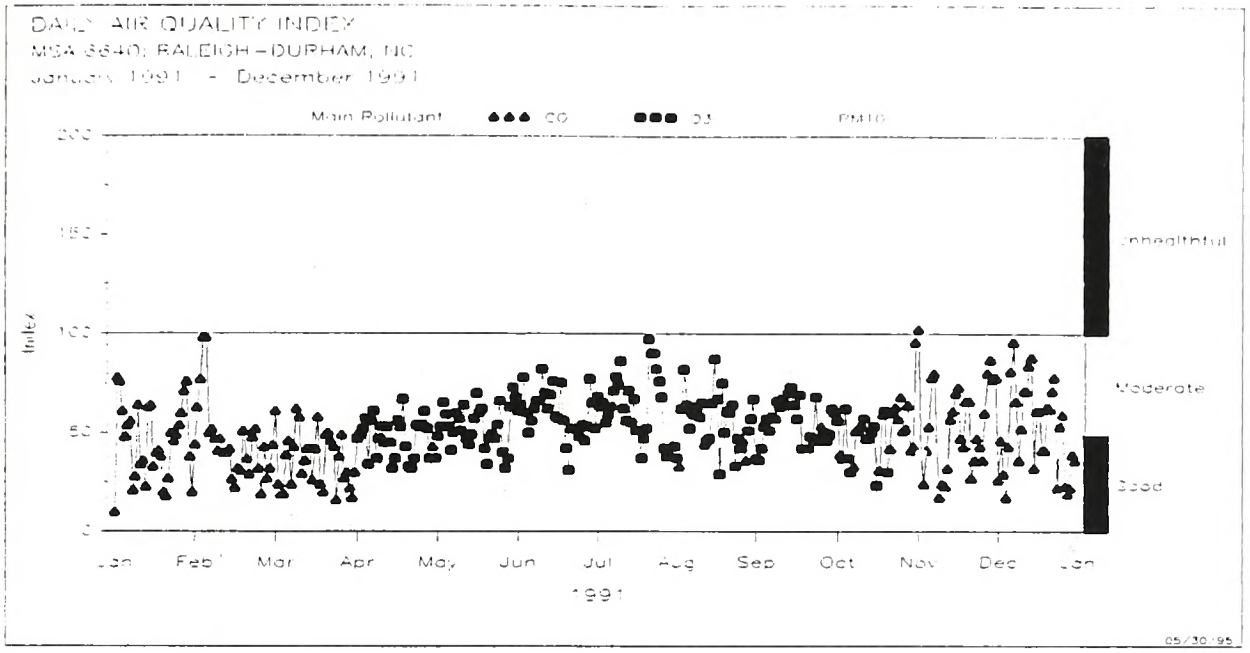


Figure 6.1. Daily Air Quality Index Values for Raleigh-Durham, North Carolina Metropolitan Statistical Area, 1991.

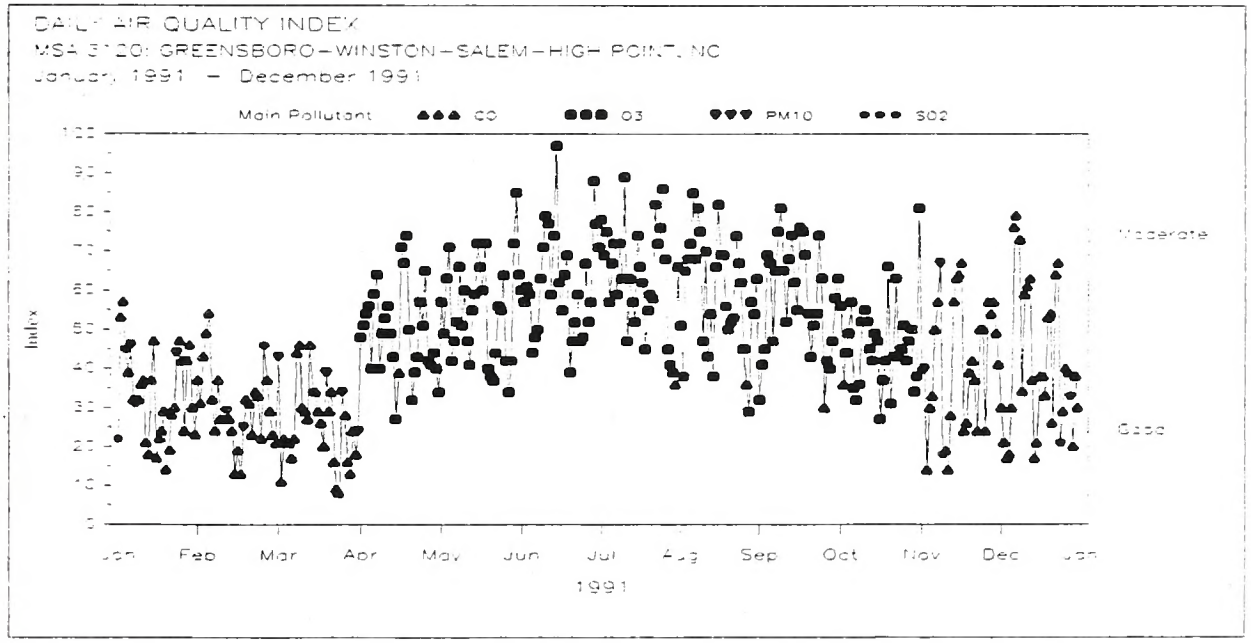


Figure 6.2. Daily Air Quality Index Values for Greensboro-Winston-Salem-High Point, North Carolina Metropolitan Statistical Areas, 1991.

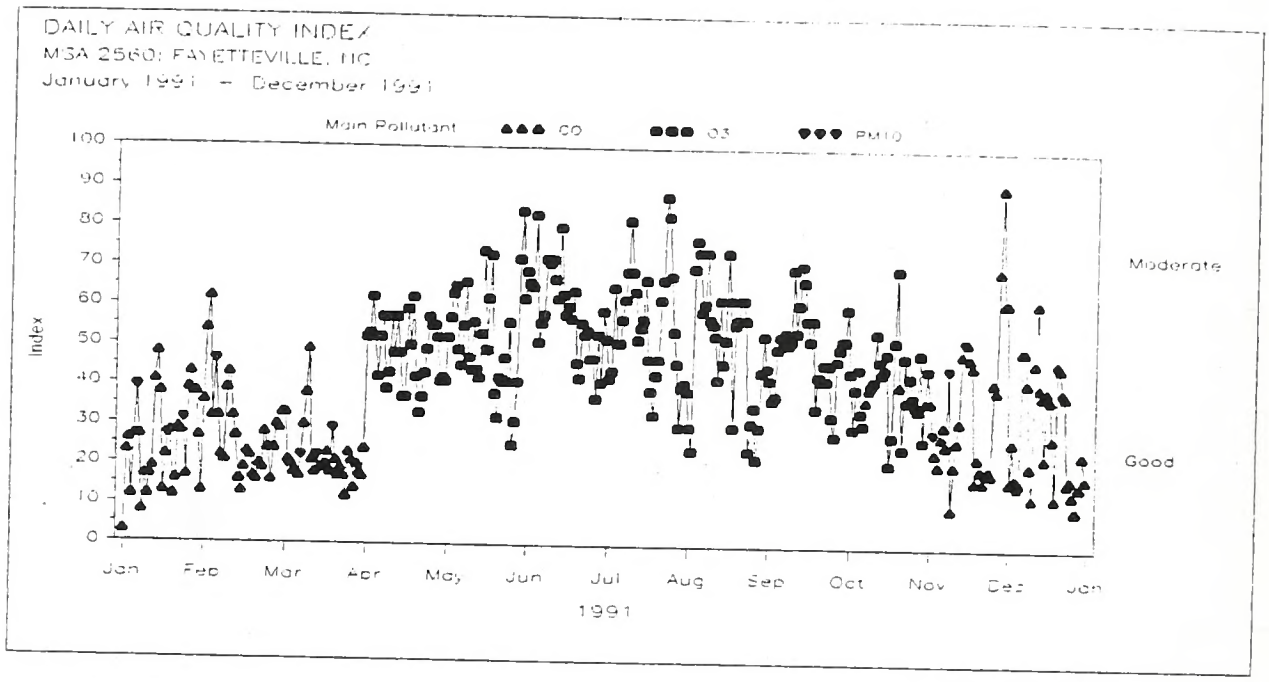


Figure 6.3. Daily Air Quality Index Values for Fayetteville, North Carolina Metropolitan Statistical Areas, 1991.

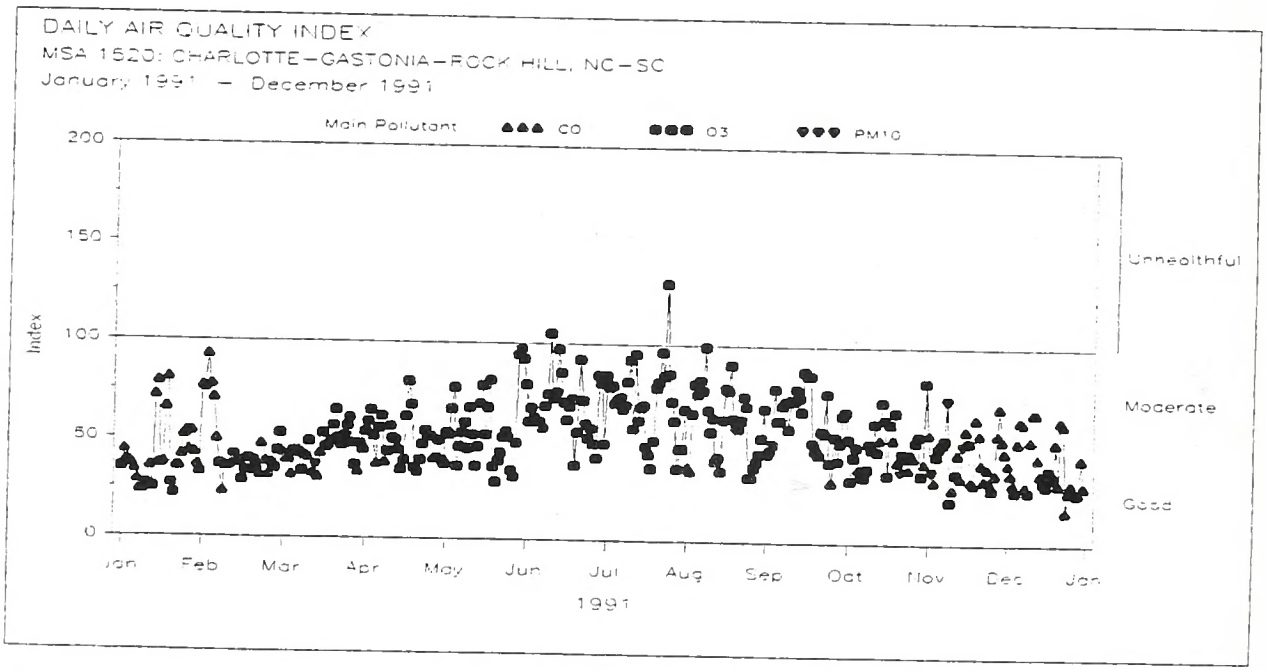


Figure 6.4. Daily Air Quality Index Values for Charlotte-Gastonia, North Carolina-Rock Hill, South Carolina Metropolitan Statistical Areas, 1991

7. Acid Rain

7.1. Sources

Acid rain is produced when nitrate and sulfate ions from automobile and industrial sources are released into the upper atmosphere, undergo a reaction with moisture in the air and are deposited as acid precipitation. Acid ions are produced when sulfur dioxide and nitrogen oxides reach equilibrium with water to form sulfuric acid and nitric acid.

7.2. Effects

Many agricultural crops in North Carolina are sensitive to acid rain. Forests are subject to mineral loss from acid rain exposure and may also suffer root damage. Acid fogs and mists, typical in the mountains of North Carolina, can expose trees and plants to even higher acid concentrations and cause direct damage to foliage. Lakes, rivers and streams that are too acidic impede fish and plant growth.

7.3. Monitoring

Acid rain monitoring has been conducted nationally, including in North Carolina, since 1978 by the National Atmospheric Deposition Program (NADP) and the National Trends Network (NTN) which merged with NADP in 1982. In 1991, acid rain samples were collected at seven sites in North Carolina and one Tennessee site in the Great Smoky Mountains less than 10 miles from the western border of North Carolina.

NADP/NTN conducts acid deposition monitoring using a wet/dry bucket type sampler. When rainfall is detected, a sensor is activated and a metal lid automatically covers and protects the "dry" sample, exposing the "wet" bucket to collect precipitation.

Acidity is measured using a "pH" scale, where pH signifies the negative logarithm of the hydronium ion concentration of water. The pH scale is numbered from 0 to 14, with 0 being extremely acidic and 14 being extremely basic. A substance with a pH of five is ten times as acidic as one with a pH of six, 100 times as acidic as a substance with a pH of seven, etc. Neutral water with an equal concentration of acid and base ions has a pH of seven. The pH of vinegar is approximately 2.8, and lemon juice has a pH of about 2.3. The pH of ammonia is approximately 12.

Pure water in equilibrium with the air is slightly acidic and has a pH of approximately 5.6. The measurements of pH at the North Carolina monitoring sites in 1991 ranged from 4.44 to 4.61 with a mean of 4.54. The 1991 pH annual means for North Carolina from the NADP/NTN database are presented in Figure 7.1 and Table 7.1. Table 7.1 also exhibits conductivity averages and precipitation totals for rainfall. Measured concentrations of several other

chemical constituents of precipitation are given in Table 7.2.

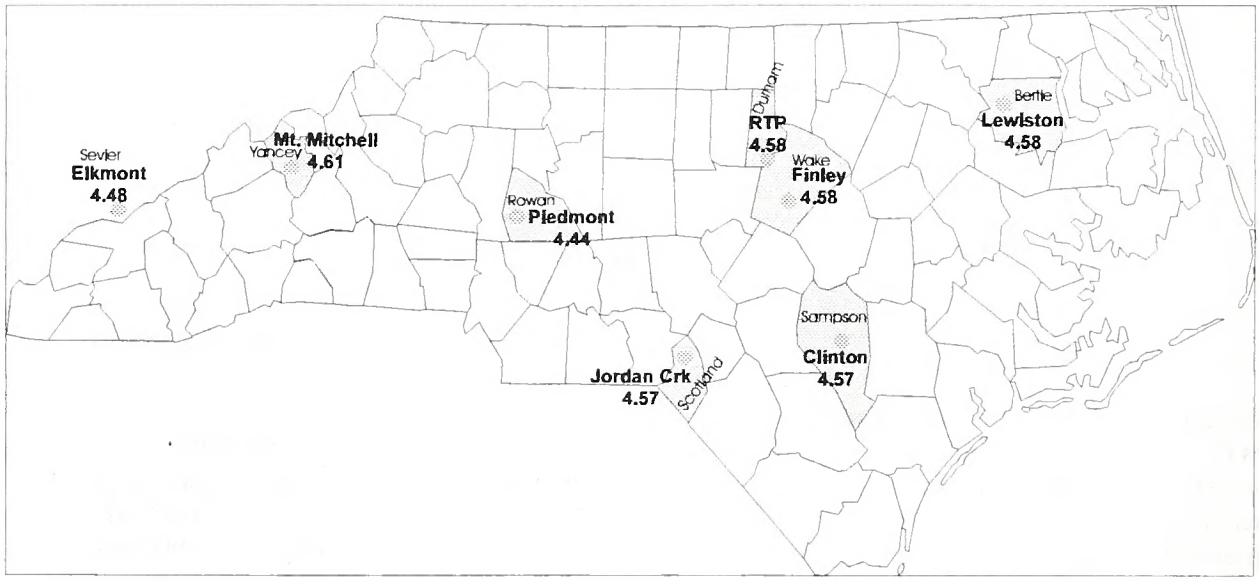


Figure 7.1. Annual Mean pH Values at North Carolina NADP/NTN/NDDN Sites, 1991

Table 7.1. pH, Conductivity in Microsiemans per Centimeter and Precipitation in Inches from the National Atmospheric Deposition Program/National Trends Network and National Dry Deposition Network Data For 1991.

COUNTY SITE ADDRESS	pH	Conductivity	Precipitation
Bertie 340320 Lewston	4.58	14.6	48.8
Macon 342500 Coweeta	4.58	14.8	68.1
Rowan 343460 Piedmont Research Station	4.44	21.2	36.5
Sampson 343560 Clinton Crops Res. Station	4.57	15.8	48.9
Scotland 343600 Jordan Creek	4.46	18.6	42.9
Wake 344160 Finley Farm	4.59	16.7	38.4
Yancey 344500 Mt. Mitchell	4.61	13.3	53.0
Sevier (TN) 441190 Great Smoky Mts Nat'l Park Elkmont TN	4.48	17.8	63.6

Table 7.2. Ion Concentrations in Milligrams per Liter (Precipitation-weighted Annual Means) from the National Atmospheric Deposition Program/National Trends Network and National Dry Deposition Network Data for 1991.

COUNTY SITE ADDRESS	% com- pleteness	Ca	Mg	K	Na	NH4	NO3	Cl	SO4
Bertie 340320 Lewston	96.1	0.04	0.02	0.01	0.14	0.15	0.82	0.26	1.24
Macon 342500 Coweeta	96.2	0.08	0.02	0.03	0.14	0.13	0.75	0.23	1.37
Rowan 343460 Piedmont Research Station	96.1	0.09	0.03	0.03	0.22	0.25	1.23	0.32	2.02
Sampson 343560 Clinton Crops Res. Station	100	0.04	0.02	0.02	0.16	0.22	0.86	0.30	1.47
Scotland 343600 Jordan Creek	92.3	0.06	0.02	0.02	0.16	0.16	1.09	0.29	1.59
Wake 344160 Finley Farm	96.1	0.06	0.03	0.04	0.18	0.34	1.01	0.32	1.56
Yancey 344500 Mt. Mitchell	54.8	0.03	0.01	0.01	0.08	0.14	0.63	0.14	1.29
Sevier (TN) 441190 Great Smoky Mts Nat'l Park Elkmont TN	92.3	0.09	0.01	0.04	0.06	0.17	0.87	0.12	1.71

8. Statewide Trends

An analysis of long term trends in North Carolina, statewide and within the individual Air Quality Control Regions, was published recently, covering air pollutant concentrations from 1972 through 1989 (North Carolina Department of Environment, Health, and Natural Resources 1991). Such a review of year-to-year changes is helpful in evaluating the success of programs intended to reduce pollution and in prioritizing future efforts. The next detailed update of the trends report is planned for 1996. Here, some interim analyses are provided at the statewide level.

8.1. Particulate Matter

The statewide distribution of second-largest 24-hour PM_{10} concentrations for each monitor from 1985 to 1991 is shown in Figure 8.1. Concentrations have been fluctuating about 58 $\mu g/m^3$ (40 percent of the standard), and no clear trend is apparent for this short series of years.

8.2. Carbon Monoxide

The statewide distribution of second-largest one-hour CO concentrations from 1973 to 1991 is shown in Figure 8.2. The mean value of this concentration has decreased from 25.9 ppm in 1973 to 18.8 ppm in 1980 (an average of 3.9 percent per year) and from 16.3 ppm in 1981 to 9.3 ppm in 1991 (five percent per year).

North Carolina has never experienced an exceedance of the one-hour NAAQS from 1973 through 1991.

The statewide distribution of second-largest eight-hour CO concentrations from 1973 to 1991 is shown in Figure 8.3. The mean value of this concentration has decreased from 15.6 ppm in 1973 to 9.9 ppm in 1980 (an average of 5.5 percent per year) and from 8.9 ppm in 1981 to 5.9 ppm in 1991 (3.7 percent per year).

Since there have been over 700 exceedances of the 8-hour NAAQS from 1973 through 1991, the number of exceedances per year is shown in Figure 8.4. The average number of exceedances decreased steadily from about 60 per year in 1973-75 to 50 per year in 1978, then it stayed approximately constant through 1983, and finally decreased again, to 5 exceedances in 1989.

8.3. Ozone

The statewide distribution of second-largest one-hour ozone concentrations is shown in Figure 8.5. The mean ozone concentration has been nearly steady from 1972 to 1991, averaging 0.104 ppm (87 percent of the standard). Figure 8.5 suggests a possible downward trend beginning in 1987, but this is probably an artifact of the high concentrations experienced in 1988 due to hot and dry summer conditions.

Since there have been about 200 exceedances of the ozone NAAQS from 1972 through 1991, the number of exceedances per year is shown in Figure 8.6. The number of exceedances fluctuates considerably from year to year, between zero and 20 annually, except for 1988 when 69 exceedances occurred. The solid trend line in Figure 8.6 suggests an average of 6.4 exceedances per year from 1973 through 1984, followed by a rapid increase from 1985 through 1987 and gradual decrease from 1987 through 1991; the average number of exceedances from 1985 through 1991 is 17.7 per year. The rapid increase in this trend in 1985 can be attributed almost entirely to the 69 exceedances of 1988; if the trend is examined with that year excluded (dashed line in Figure 8.6), the number of exceedances has remained approximately constant through the entire interval from 1975 through 1991, averaging ten per year.

8.4. Sulfur Dioxide

The statewide distribution of second-largest three-hour SO_2 concentrations from 1972 to 1991 is shown in Figure 8.7. The mean decreased from 831 $\mu g/m^3$ in 1972 to 710 $\mu g/m^3$ in 1983 (55 percent of the standard) and had remained approximately constant at that level through 1991.

The statewide distribution of second-largest 24-hour SO_2 concentrations from 1972 to 1991 is shown in Figure 8.8. The mean has been approximately constant around 33.4 $\mu g/m^3$ (9 percent of the standard) from 1973 through 1991.

8.5. Nitrogen Oxides

The statewide distribution of annual mean NO_2 concentrations from 1972 to 1991 is shown in Figure 8.9. The mean concentration has decreased from 0.0204 ppm in 1978 to 0.0151 ppm in 1991 (28 percent of the standard), or about 2.1 percent per year.

8.6. Lead

The statewide distribution of quarterly lead concentrations is shown in Figure 8.10, using all available data from 1972 through 1990. The mean lead concentration decreased from 0.125 in 1985 to 0.028 in 1988 and 0.019 in 1990, an average annual decrease of 40 percent from 1985 to 1988 and 17 percent from 1988 to 1990.

8.7. pH

The statewide distribution of annual mean pH values from 1978 to 1991 for the NADP/NTN sites (including two collocated sites and the Great Smoky Mountain, Tennessee site) is shown in Figure 8.11. The mean pH has fluctuated between 4.44 and 4.57, showing no indication of a changing trend.

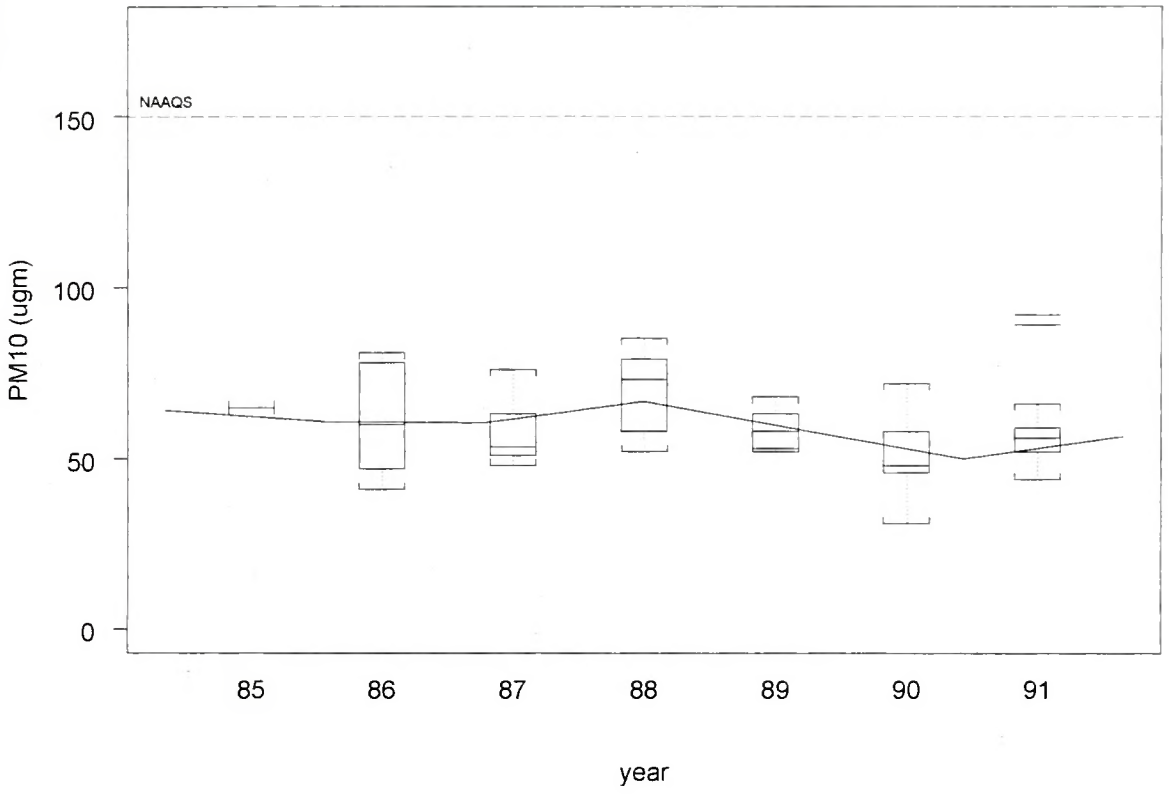


Figure 8.1. Distribution of Statewide 24-hour PM_{10} Concentrations 1985-91, and Smoothed Regression Trend Line

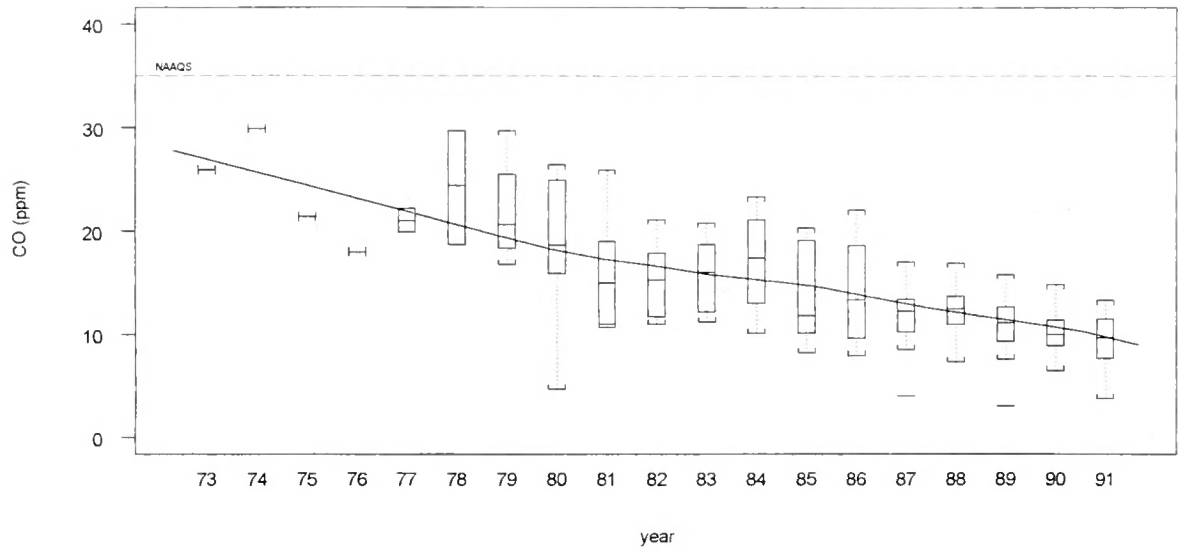


Figure 8.2. Distribution of Statewide 1-hour CO Concentrations 1973-91, and Smoothed Regression Trend Line

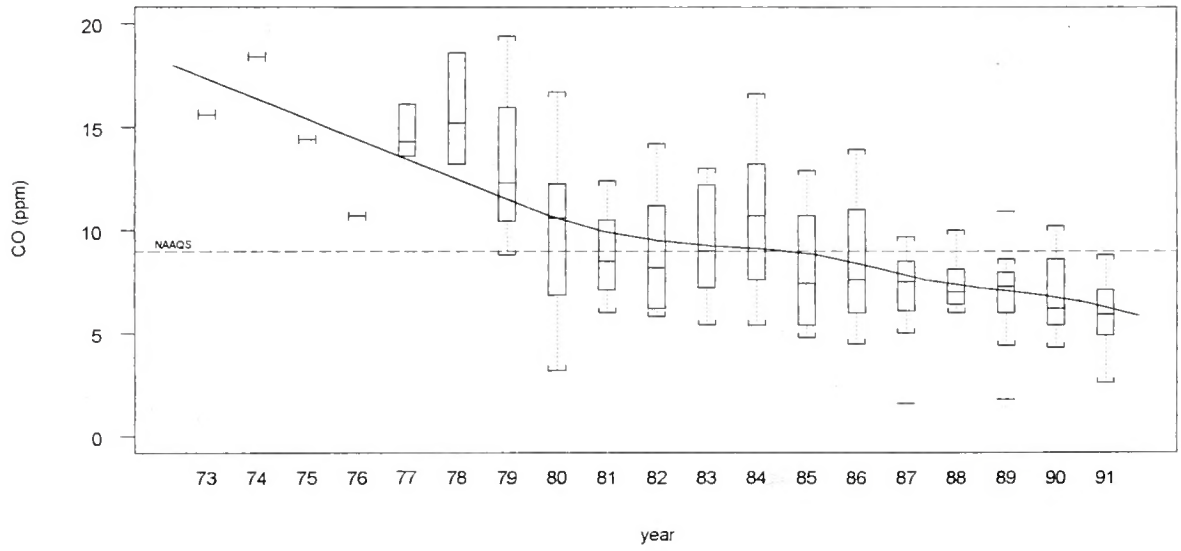


Figure 8.3. Distribution of Statewide 8-hour CO Concentrations 1973-91, and Smoothed Regression Trend Line

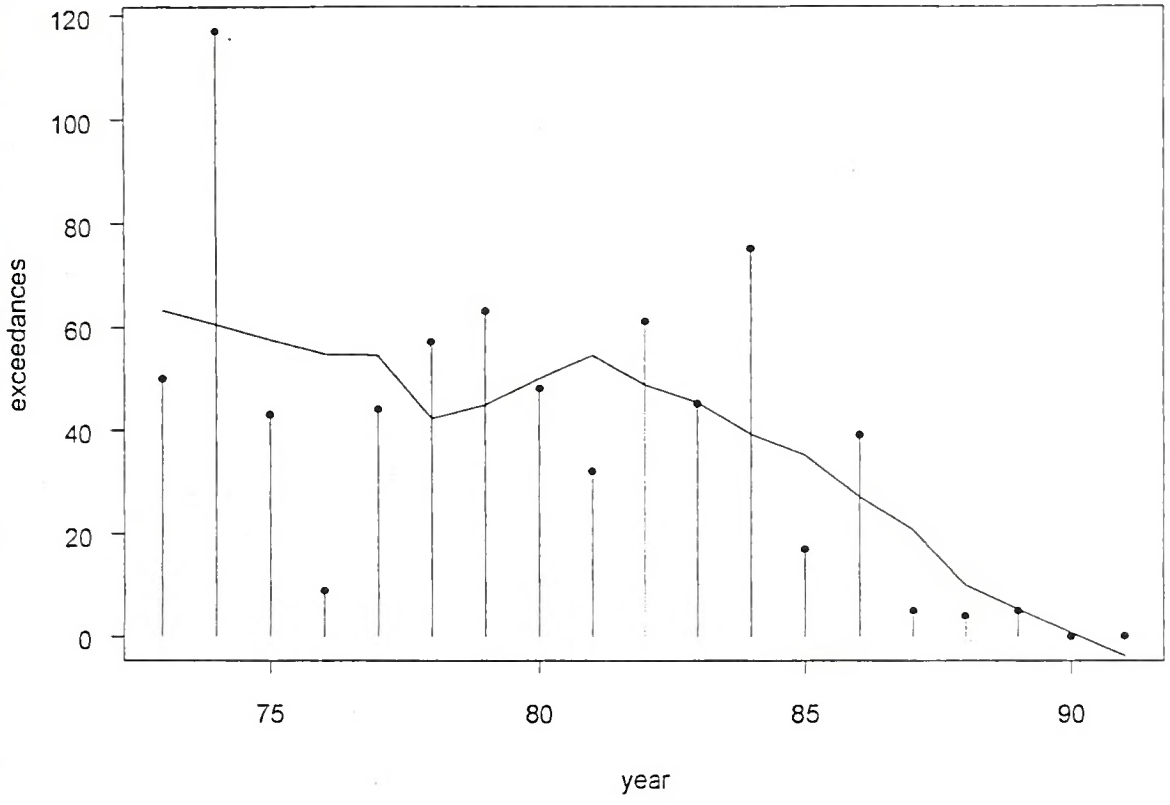


Figure 8.4. Number of Exceedances of 8-hour CO NAAQS, 1973-91, and Smoothed Regression Trend Line

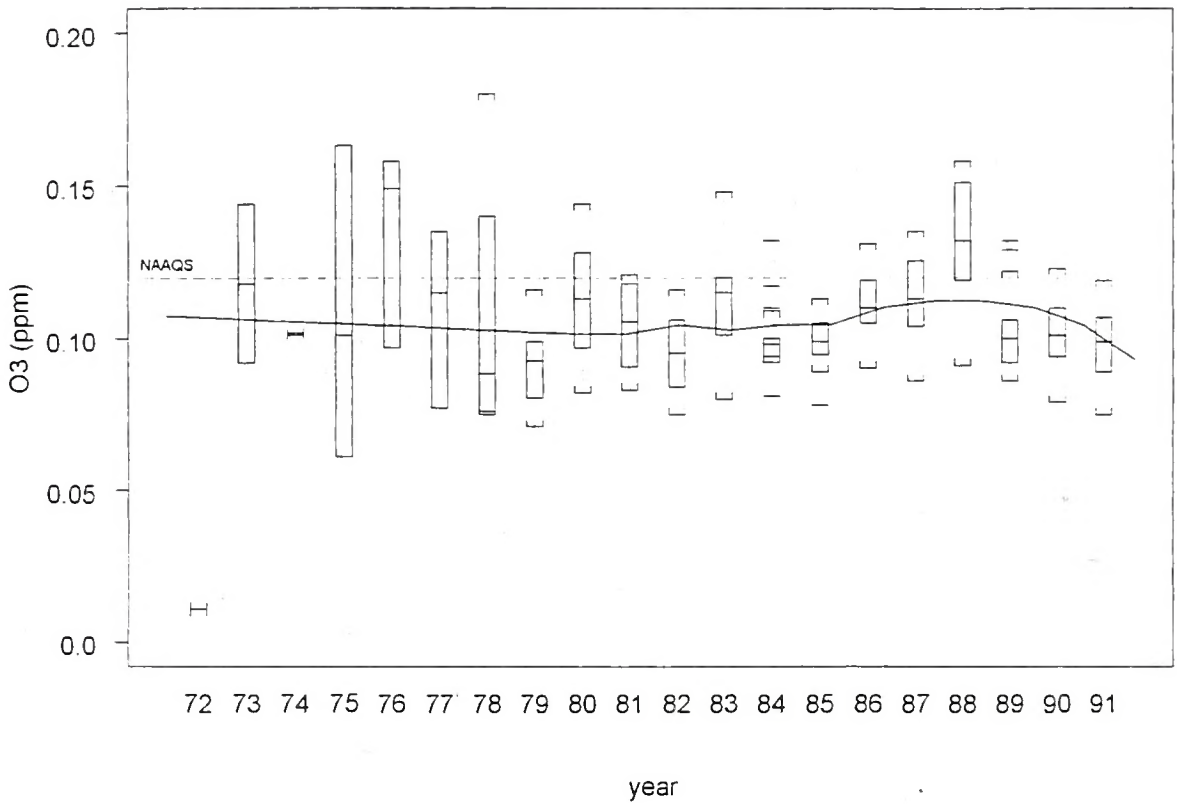


Figure 8.5. Distribution of Statewide 1-hour O_3 Concentrations 1972-91, and Smoothed Regression Trend Line

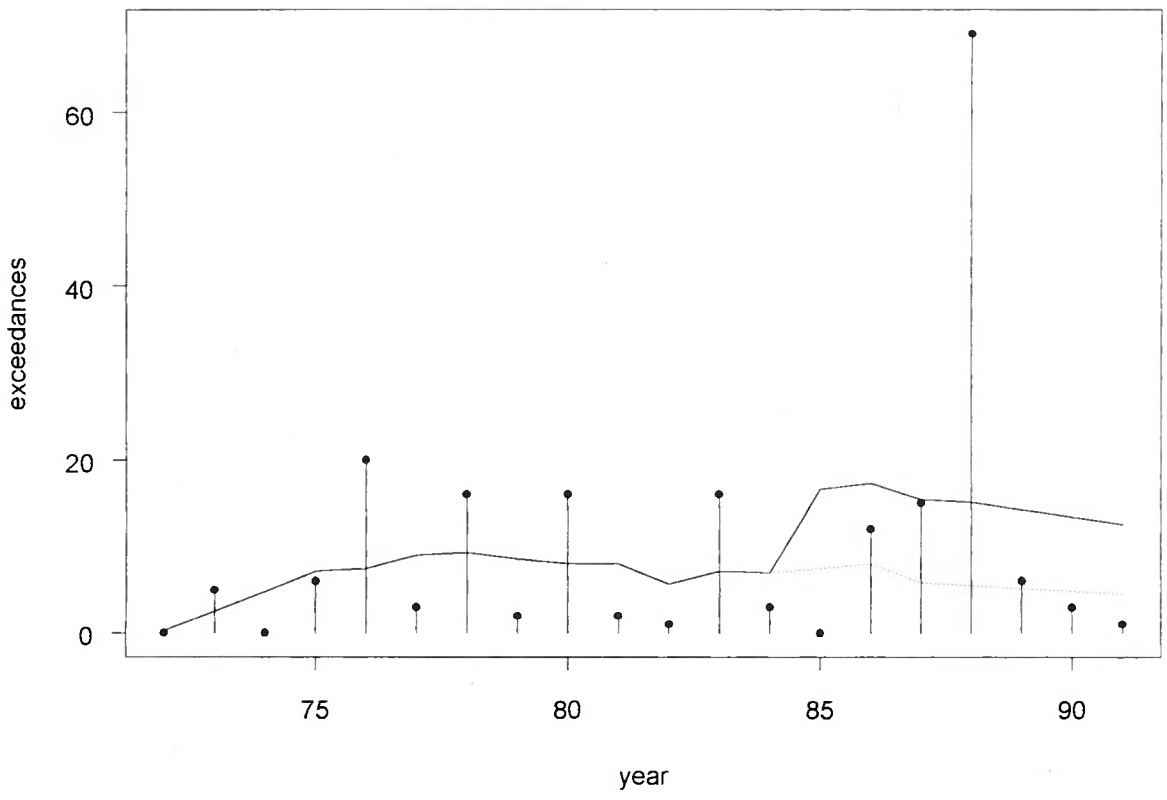


Figure 8.6. Number of Exceedances of Ozone NAAQS, 1972-91, and Smoothed Regression Trend Lines. Dotted trend line treats the 1989 data value as an outlier.

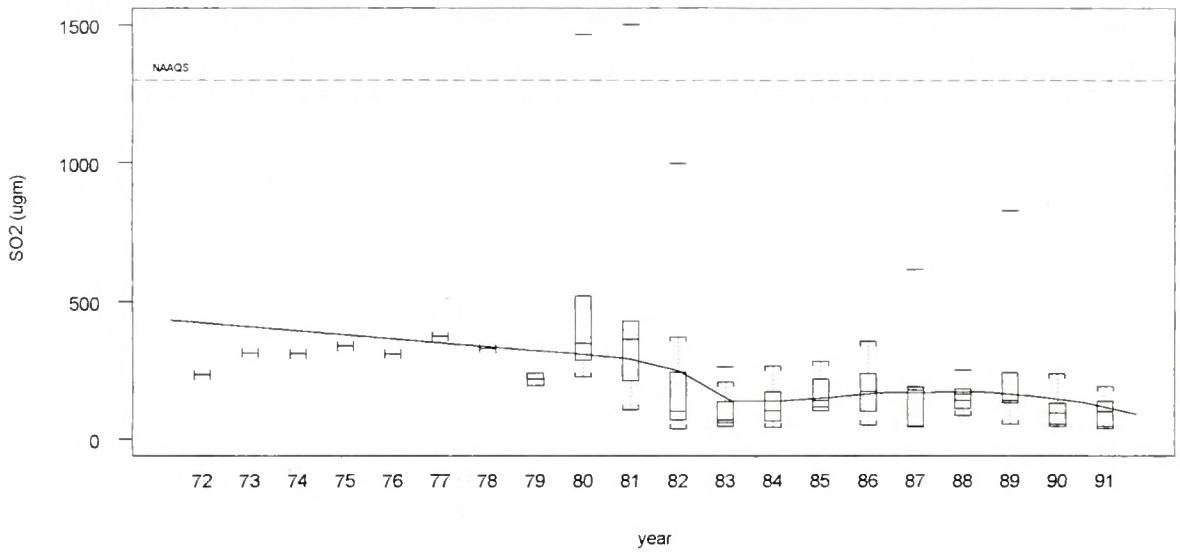


Figure 8.7. Distribution of Statewide 3-hour SO_2 Concentrations 1973-91, and Smoothed Regression Trend Line

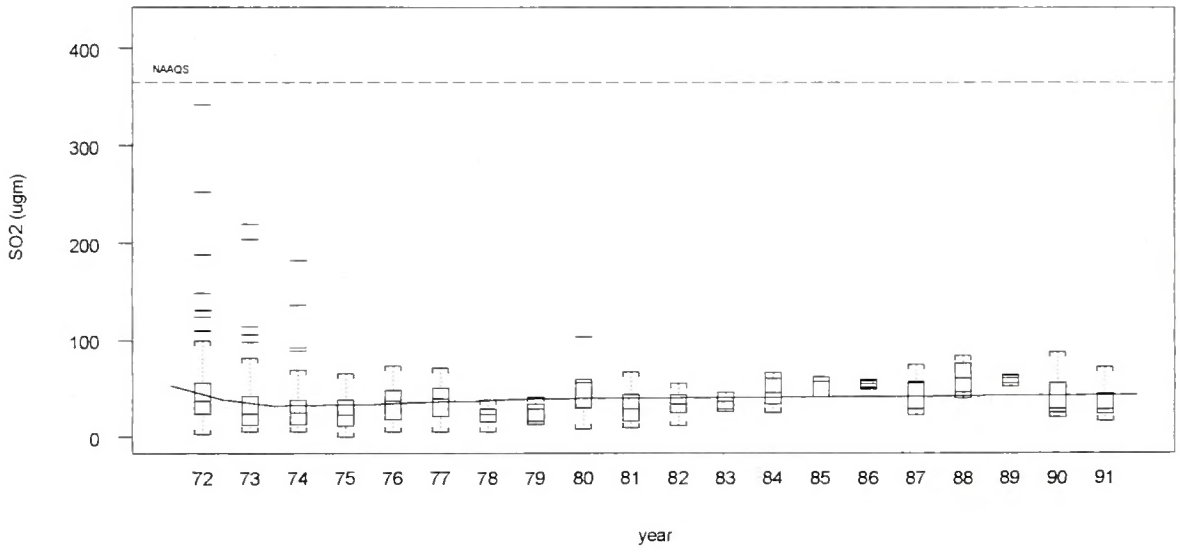


Figure 8.8. Distribution of Statewide 24-hour SO_2 Concentrations 1973-91, and Smoothed Regression Trend Line

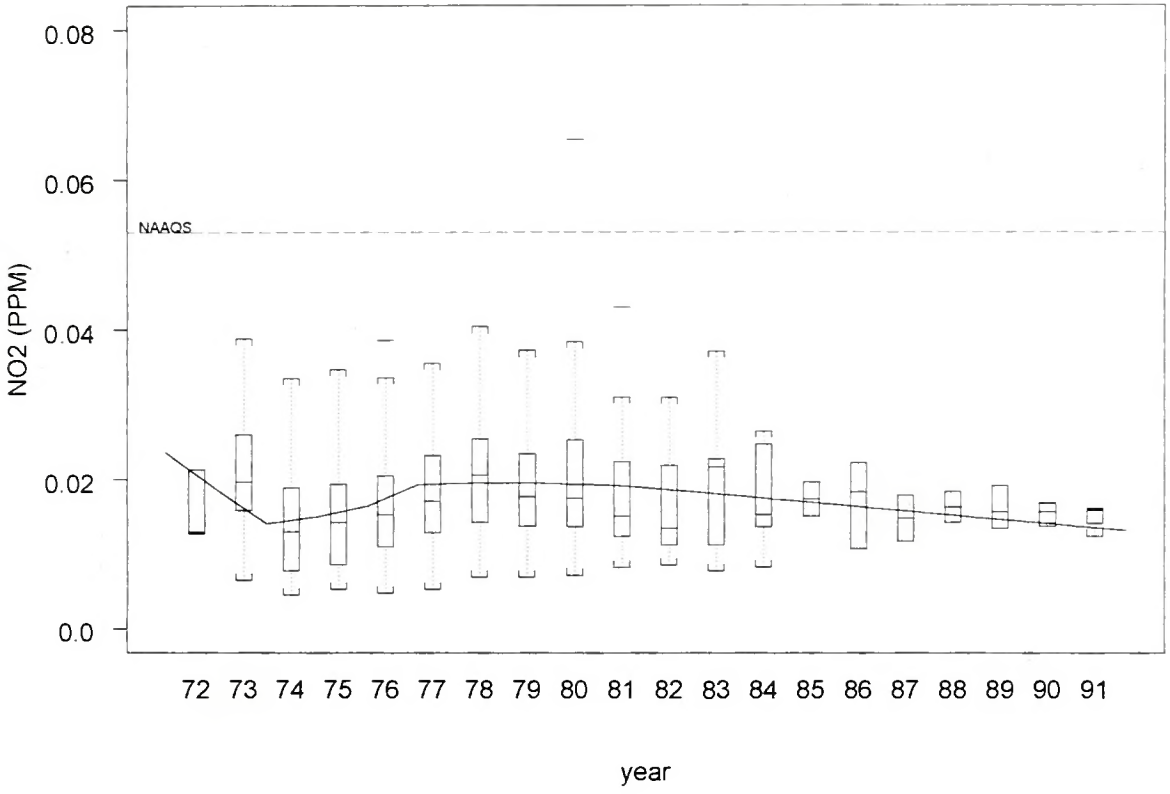


Figure 8.9. Distribution of Statewide Annual Mean NO_2 Concentrations 1972-91, and Smoothed Regression Trend Line

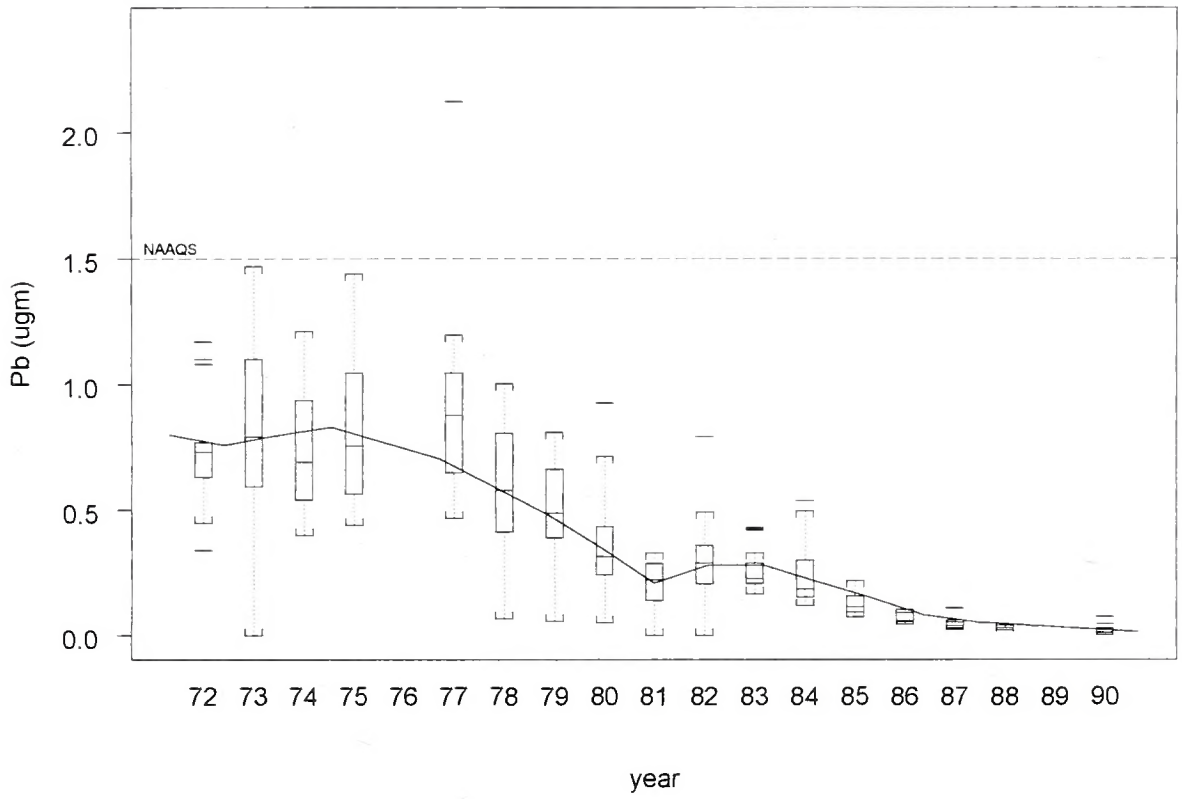


Figure 8.10. Distribution of Statewide Quarterly Lead Concentrations 1972-90, and Smoothed Regression Trend Line

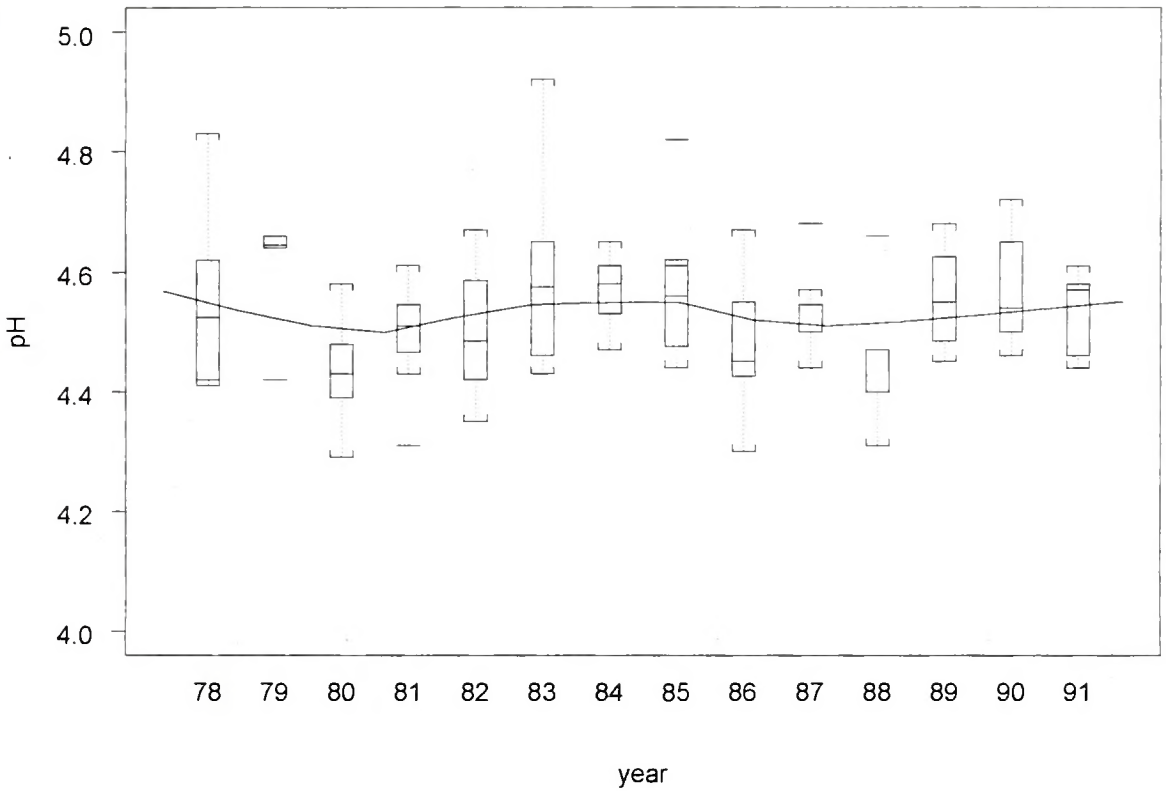


Figure 8.11. Distribution of Statewide Annual Mean pH 1978-90, and Smoothed Regression Trend Line

References

North Carolina Department of Environment, Health, and Natural Resources (1991a). 1989 Ambient Air Quality Report. *Air Quality Section, Division of Environmental Management, N.C. Dept. Of Env., Health, and Nat. Res.*

North Carolina Department of Environment, Health, and Natural Resources (1991). Ambient Air Quality Trends in North Carolina 1972-1989. *Air Quality Section, Division of Environmental Management, N.C. Dept. Of Env., Health, and Nat. Res.*

Office of the Federal Register (National Archives and Records Administration) (1993), "Code of Federal Regulations, Title 40, Parts 1 to 51, Protection of Environment," (July 1 ed.), Washington, DC: Author.

Appendix A. Air Pollution Monitoring Agencies

North Carolina State Headquarters

Division of Environmental Management
Archdale Building
512 North Salisbury Street
P O Box 29535
Raleigh, North Carolina 27626-0535
(919) 733-3340

[Effective 1996]
Division of Air Quality
Parker Lincoln Building
2728 Capital Boulevard
P O Box 29580
Raleigh, North Carolina 27626-0580
(919) 715-0665

North Carolina Regional Offices

Asheville Regional Office
Interchange Building
59 Woodfin Place
Asheville, North Carolina 28801
(704) 251-6208

Counties of Avery, Buncombe, Burke, Caldwell, Cherokee, Clay, Graham, Haywood, Henderson, Jackson, Macon, Madison, McDowell, Mitchell, Polk, Rutherford, Swain, Transylvania, and Yancey.

Fayetteville Regional Office
Suite 714
225 Green Street
Fayetteville, North Carolina 28301
(919) 486-1541

Counties of Anson, Bladen, Cumberland, Harnett, Hoke, Montgomery, Moore, Robeson, Richmond, Sampson, and Scotland.

Mooresville Regional Office
919 North Main Street
P.O. Box 950
Mooresville, North Carolina 28115-0950
(704) 663-1699

Counties of Alexander, Cabarrus, Catawba, Cleveland, Gaston, Iredell, Lincoln, Mecklenburg, Rowan, Stanly and Union.

Raleigh Regional Office
3800 Barrett Drive
P.O. Box 27687
Raleigh, North Carolina 27611
(919) 733-2314

Counties of Chatham, Durham, Edgecombe, Franklin, Granville, Halifax, Johnston, Lee, Nash, Northampton, Orange, Person, Vance, Wake, Warren, and Wilson.

Washington Regional Office
1424 Carolina Avenue
P.O. Box 1507
Washington, North Carolina 27889-3314
(919) 946-6481

Counties of Beaufort, Bertie, Camden, Chowan, Craven, Currituck, Dare, Gates, Greene, Hertford, Hyde, Jones, Lenoir, Martin, Pamlico, Pasquotank, Perquimans, Pitt, Tyrrell, Washington, and Wayne.

Wilmington Regional Office
7225 Wrightsville Avenue
Wilmington, North Carolina 28403-7293
(919) 256-4161

Counties of Brunswick, Carteret, Columbus, Duplin, New Hanover, Onslow and Pender.

Winston-Salem Regional Office
8025 North Point Boulevard
Winston-Salem, North Carolina 27106-3256
(919) 896-7007

Counties of Alamance, Alleghany, Ashe, Caswell, Davidson, Davie, Forsyth, Guilford, Rockingham, Randolph, Stokes, Surry, Yadkin, Watauge, and Wilkes.

Local Agencies

Forsyth County Environmental Affairs Department
537 North Spruce Street
Winston-Salem, North Carolina 27101
(919) 727-8064

Mecklenburg County Department of Environmental Protection
1200 Blythe Boulevard
Charlotte, North Carolina 28203
(704) 376-4603

Western North Carolina Regional Air Pollution Control Agency
Buncombe County Courthouse Annex
Asheville, North Carolina 28801-3569
(704) 255-5655

Counties of Buncombe and Haywood.

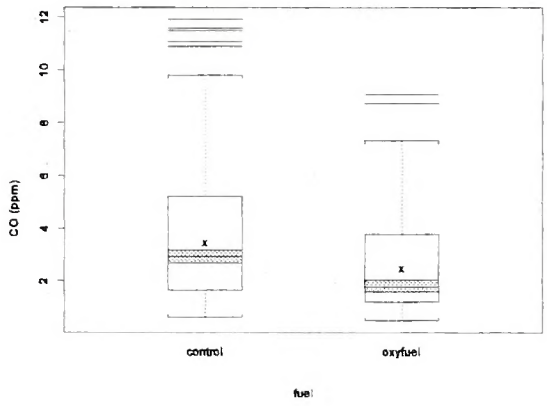
Appendix B. Exceptional Events

Type of Event	Pollutants Affected
Natural Events	
Sustained high wind speeds	particulate matter (PM)
Stagnations, inversions	all pollutants
Unusual lack of precipitation	PM
Stratsopheric ozone intrusion	O_3
Volcanic eruption	CO, SO_2, PM
Forest fires	CO, PM
High pollen count	PM
Unintentional Manmade Events	
Large structural fires	CO, PM
Major traffic congestion due to accident or nonrecurring obstruction	CO
Chemical spills	SO_2, NO_2, PM, CO
Industrial accidents	SO_2, NO_2, PM, CO
Intentional Manmade Events	
Short-term construction/demolition	PM
Sandblasting	PM
High-sulfur oil refining	SO_2
Roofing operations	PM, SO_2
Salting or sanding of streets	PM
Infrequent large gatherings	PM, CO
Soot blowing from ships	PM
Agricultural tilling	PM
Prescribed burning	CO, PM
Noncompliance of local sources	CO, SO_2

Appendix C. Box-And-Whisker Plots

A *box-and-whisker plot* (also called *boxplot* or *schematic plot*) is a schematic diagram useful for depicting the location, spread and skewness of a continuous data variable. Box plots are constructed from *order statistics* (data values sorted from smallest to largest). The "box" of the box plot is oriented parallel to a continuous scale and is defined by 3 points, (i) a line or point in the interior of the box at the median of the data (a point that divides the order statistics into two equal parts), and (ii, iii) upper and lower *fourths* or *quartiles*. (Fourths divide the upper and lower halves of the data values into two equal parts; quartiles divide the entire range of the data into 4 equal parts. Fourths and quartiles are not necessarily the *same*, because there may be more than one number that appropriately divides a given set of data in the prescribed way, and different computational techniques [or computer programs] may make different choices.)

The distance between the upper and lower fourth in the box plot is called the *interquartile range*. In most box plots, the length of each of the *whiskers* is 1.5 times the interquartile range or to the extreme (maximum or minimum) of the data, whichever is *shorter*. The endpoint of each whisker is called an *inner fence*. (In the box plots pictured below, the end of each whisker is marked by a "staple" for clarity.) There may be data points, called *outliers*, beyond the inner fences; if so, they are usually indicated individually on the box plot by a dot, small circle, or (as below) a short line segment perpendicular to the axis of the box. Box plots of variables with very long-tailed distributions may display two kinds of outliers—small dots for those just beyond the inner fences and larger dots or circles for *extreme outliers* at a distance of more than 3.0 times the interquartile range beyond the fourths. This boundary between outliers and extreme outliers is termed the *outer fence* and usually not explicitly shown in the plot.



The maximum and minimum values are always visible in a box-and-whisker plot as either the outermost outliers or, if there is no outlier, the position of the inner fence.

Box plots may have additional, optional features, such as a point marker at the *arithmetic mean* or a distinctive display of a *confidence interval for the median*, which is calculated from the fourths. In the figure, the arithmetic mean is marked with an "X", and the confidence interval for the median is displayed as a shaded or colored range; it is also common to display the confidence interval by cutting notches in the sides of the box at its endpoints.

Box plots are very useful for comparing two or more variables by placing two comparable variables side-by-side on the same scale (as in the figure). The statistics displayed can be directly compared, and statistical significance of difference between the medians can be assessed by examining overlap or lack of overlap of confidence intervals.

Appendix D. Nonattainment and North Carolina

What is nonattainment and what are the sources of the pollutants?

The United States Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards. North Carolina monitors concentrations of air pollutants in the ambient air. Some of these monitors have measured concentrations of ozone and carbon monoxide exceeding the Standards. Areas that have not met the National Ambient Air Quality Standards can be classified by EPA as"nonattainment".

Mobile sources are the primary cause of carbon monoxide and ozone precursors. Around 90 percent of the carbon monoxide emissions come from motor vehicles. Thirty percent to 50 percent of the man-made hydrocarbons or volatile organic compound emissions come from motor vehicles; the rest comes from petroleum marketing, factories, businesses, and households. Volatile organic compounds react with nitrogen oxides and sunlight in warm weather to produce ozone.

Why is my county nonattainment?

Unless the state can demonstrate a better alternative, EPA has indicated that they will designate nonattainment areas based on Metropolitan Statistical Areas (MSAs). These MSAs were established by the Office of Management and Budget. Monitors showing violations of Standards may not be in every county. Previous emission control programs instituted in single counties across the nation have often failed to produce compliance with Standards. Pollution from one county blows into neighboring counties (especially ozone). EPA concluded that the control plans must cover metropolitan areas, not single counties.

Once we are nonattainment, what is the process for becoming attainment?

North Carolina is required by the federal Clean Air Act and EPA to produce and implement emission reduction plans and show that these plans are strong enough to produce compliance with the Standards. The plans could involve resource-intensive monitoring, emissions inventory, modeling, public participation, and strategy formulation efforts. There are deadlines for producing the plans and for achieving compliance with the Standards. EPA must approve the plans.

How does the public get involved in the formulation of the emission reduction plans, known as State Implementation Plan (SIP) revisions?

Local agencies and officials, as well as state agencies, will be involved in drawing up the SIP revisions. It is likely that there will be public meetings or ad hoc citizen panels. When draft SIP revisions are done, there will be public hearings on them. The SIP revisions must be approved by the Environmental Management Commission and possibly by local bodies as well. EPA's approval process includes an opportunity for public comment.

How will it affect the citizen?

Emission reduction strategies fall into several categories. Motor vehicle inspection/maintenance may be required for hydrocarbons or carbon monoxide or both. Traffic patterns may be altered by changing roads or traffic signals. Both new and existing factories and business may have to reduce emissions by installing control equipment or changing processis. This might include requiring that gas stations trap vapors that escape when a vehicle is refueled or that gasoline contain pollution-reducing additives.

What happens if North Carolina refuses to address these air pollution problems?

Under the Clean Air Act, EPA has the authority to apply sanctions. EPA can ban the construction of major pollutant sources, and may withhold federal highway construction funds in the nonattainment areas.

What is the likelihood of receiving sanctions if we are showing progress in reducing pollution?

If North Carolina were to produce SIP revisions that EPA can approve by the deadlines and were to carry out those plans, sanctions could be avoided. If pollution concentrationd did not recede and attain the Standards as projected, construction bans could be imposed. EPA has some discretion about imposing sanctions. Sanctions are a last step to persuade states to take required positive action.

What does inspection/maintenance cost?

The inspection/maintenance (I/M) of motor vehicle tailpipe testing process costs the motorist $15.40 as of October 1, 1990. If a vehicle fails the test, it must be repaired. A waiver is available if a vehicle still fails after $50.00 worth of repairs have been done. The $50.00 limit does not apply to tampered or misfueled vehicles. The inspection/maintenance program includes tests for hydrocarbon (HC) and carbon monoxide (CO) emissions. Currently Mecklenburg and Wake Counties have I/M programs. Testing for HC began in April of 1991. Guilford and Forsyth counties started I/M programs in July of 1991. Only gasoline powered motor vehicles built after 1974, excluding the current model year and motorcycles, are inspected in these counties. Inspection/maintenance pass-fail levels vary with vehicle age and pollutant.

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